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A
REFERENCE HANDBOOK
OF THE
MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE
AND
ALLIED SCIENCE

BY VARIOUS WRITERS

ILLUSTRATED BY CHROMOLITHOGRAPHS AND FINE WOOD ENGRAVINGS

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

VOLUME VIII.

NEW YORK
WILLIAM WOOD & COMPANY
56 & 58 LAFAYETTE PLACE
1889.

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TROW'S
PRINTING AND BOOKBINDING COMPANY,
NEW YORK.

PREFACE TO VOLUME VIII.

In bringing the present work to its termination I desire to make full acknowledgment of my indebtedness to various individuals for the aid which they have rendered me in this undertaking. More than three hundred men and women, experts in some particular department of medical knowledge or in one of the kindred sciences, have contributed the actual text of these eight volumes. Their names are appended to the articles which they have written, and the proportionate share which each has taken in building up this reservoir of medical facts and theories, may, therefore, readily be learned upon investigation. While thanking these writers, one and all, for their valuable contributions, I must at the same time call attention to the prompt and willing manner in which many of them have accepted the most laborious tasks. I mention this fact because it reveals the existence among the corps of contributors of a strong sense of professional pride—a desire to do all in their power toward the erection of a structure that might reflect credit upon the entire medical profession of the United States and Canada. Had it not been for this strong and wide-spread professional loyalty, if I may so term it, I am confident that it would have been found necessary either to abandon the Handbook scheme altogether, or else to have made the book a mere compilation or digest of existing treatises.

In the difficult task of selecting suitable topics and writers competent to discuss them authoritatively, I have continued to receive valuable assistance from several of the gentlemen named in the preface to Volume I., and also from the following: Prof. W. T. Councilman, M.D., of the Johns Hopkins University, Baltimore; Prof. Francis J. Shepherd, M.D., of McGill University, Montreal; Dr. A. T. Cabot, of Boston; and Prof. R. A. Witthaus, M.D., Prof. M. Allen Starr, M.D., Dr. Theodore H. Kellogg, and Dr. Leopold Putzel, of this city. To these gentlemen, and to those named in Volume I., I am very largely indebted for whatever degree of credit the editorial part of the undertaking may deserve.

Finally, I owe it to the publishers to say that from the beginning to the end of the work they have done everything that a generous, and when necessary lavish, expenditure of time and money could do to enable me to make the book as complete and as useful as possible to the profession.

The credit for the General Index is entirely due to Dr. Thomas L. Stedman, who from the very beginning of the enterprise has rendered me most valuable assistance.

Albert H. Buck.

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A REFERENCE HANDBOOK
OF THE
MEDICAL SCIENCES.

WORMSEED, AMERICAN (*Chenopodium*, U. S. Ph. ; *Ansérine vermifuge*, Codex Med.). The fruit of *Chenopodium ambrosioides*, var. *anthelminticum* Gray ; Order *Chenopodiaceæ*.

This is a perennial form of *Ch. ambrosioides* Linn., Mexican Tea, Ambrosia, etc., an old-fashioned garden-plant of rather pleasant odor, now rarely cultivated, but frequently growing wild about old country houses. Wormseed grows two or three feet high, has nearly leafless spikes of minute green flowers, and oblong or lanceolate, strongly toothed leaves. All parts of the plant are fragrant and covered with glandular hairs. The flower is minute, consisting of a green, five-toothed calyx, which is persistent, and encloses the fruit ; five stamens, and a single one-ovuled ovary with two styles ; fruit, a little utricle, one or two millimetres ($\frac{1}{12}$ inch) in diameter, enclosing a single, black, shiny seed, embryo coiled in a ring, around the albumen. It is a native of the warmer parts of America, north and south, and has been introduced into the United States and Europe, where it has become naturalized. It is cultivated upon a commercial scale in Maryland, where the oil of the entire plant is distilled. The fruits, generally called "seeds," are "nearly one-twelfth of an inch (2 millimetres) in diameter, depressed, globular, glandular, dull-greenish or brownish, the integuments friable, containing a lenticular, obtusely-edged, glossy, black seed. It has a peculiar, somewhat terebinthinate odor, and a bitterish, pungent taste" (U. S. Ph.).

The fruits contain one or two per cent. of a rather disagreeable, minty, essential oil, which represents it medicinally. This oil is usually distilled from the entire herb. It is a thin, and, when fresh, colorless liquid of aromatic odor and bitterish taste, sp. gr., 0.920.

Like most aromatic herbs, chenopodium, in small doses, is a stomachic tonic ; in large doses it is irritating and nauseating. The property for which it is mostly prized is, however, its poisonous action upon intestinal worms, particularly upon the lumbrici. From five to fifteen drops of the oil in emulsion or on sugar is the usual range of doses.

ALLIED PLANTS.—*Ch. Botrys*, of Europe, in the same fragrant subsection of the genus, is often cultivated for its pleasant odor. Another group of the genus contains the various pigweeds, and related genera furnish beets and spinach. The typical species, *Ch. ambrosioides*, is official in France, "*Ambroisie du Mexique*," as well as *Ch. vulvaria* Linn., "*Vulvaire*," Codex Med.

ALLIED DRUGS.—See Koosso, and the article following this.

W. P. Bolles.

WORMSEED, LEVANT (*Santonica*, U. S. Ph. ; Br. Ph. ; *Flores Cini*, G. Ph. ; *Semen contra*, *Semencine ou Barbotine*, Codex Med., etc.).

These so-called seeds are neither seeds nor fruits, but the unexpanded flower-heads of a variable and not well defined species of *Artemisia :* A. *maritima*, var. *Stechmanniana* Besser ; Order *Compositæ*. *A. maritima* is a very widely scattered species, growing along the sea-coasts of

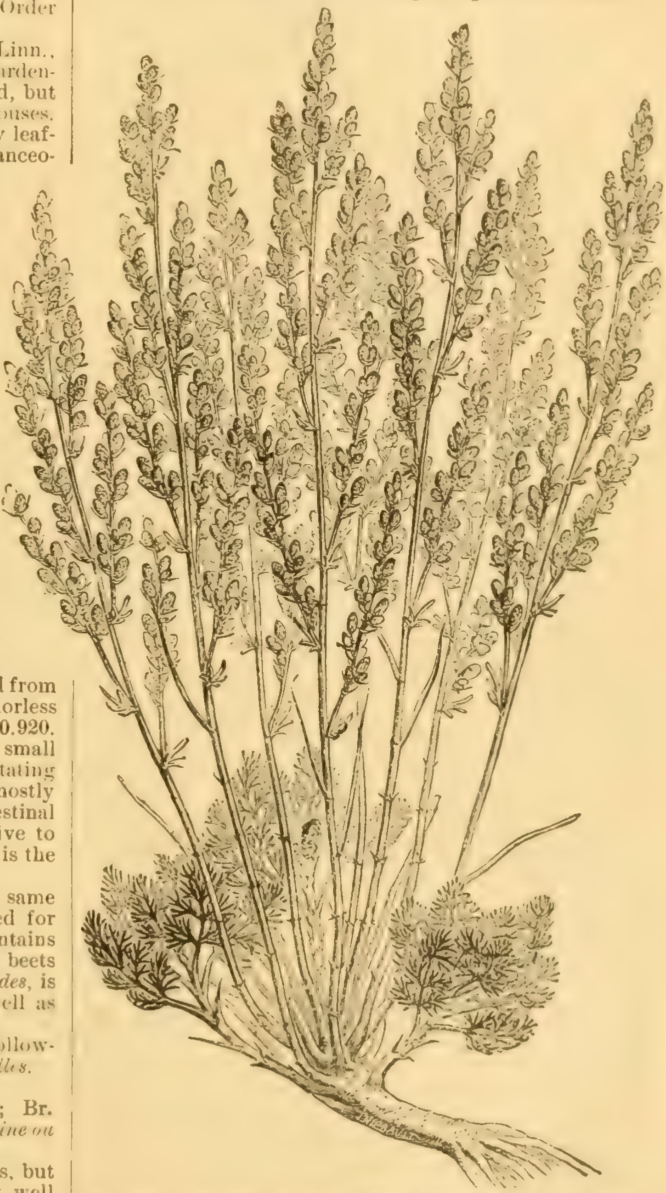

FIG. 4623.—Artemisia Pauciflora. Web. (Baillon.) The plant which, according to Baillon, furnishes the Levant Wormseed of the market.

Great Britain, France, the Mediterranean countries, in the Caspian and Black Sea basins, and elsewhere in Asia. The variety yielding Santonica grows in Southern Russia, Siberia, Asia Minor, Persia, etc., and the drug finds its way westward through St. Petersburg and the other ports of the Levant, whence its distinguishing name. Santonica is an old remedy, and without doubt has been in continuous use from the time of Dioscorides [illegible] down to the present (Pharmacographia).

It consists exclusively of the little unopened flower heads or capitula, picked just before blossoming and dried. They are about two millimetres, 1/12 inch long, ovoid, or narrowly oblong, smooth, of a greenish or brownish-green color, and so light that ninety of them weigh but a grain. They consist of an imbricated involucre of about eighteen oblong, obtuse, glandular scales, and from three to five immature tubular flowerets. No pappus. It has a strong, peculiar, camphoraceous odor, and an aromatic and bitter taste.

Composition.—Wormseed contains [illegible] volatile oil in which are cineol and camphor [illegible], and a very interesting and [illegible] crystalline principle, Santonin, to which it owes its valuable anthelmintic properties. This may be prepared by treating the wormseed with lime and alcohol, whereby the santonin is removed in combination with the lime, from which it is afterward separated, after distilling off the alcohol, by means of some acid. It is then redissolved and purified in the ordinary way. The yield is about two per cent. Santonin (Santoninum, U. S. Ph., [illegible]) is in colorless, shining, flat, rhombic prismatic crystals, not altered by exposure to air, but turning yellow on exposure to light; odorless and nearly tasteless when first placed in the mouth, but afterward bitter, and leaving a [illegible] taste. Nearly insoluble in cold water. Soluble in 250 parts of boiling water, in 40 parts of alcohol at 15° C. (59° F.), and in 8 parts of boiling alcohol; also soluble in 140 parts of ether, in 4 parts of chloroform, and in solutions of the alkalies. The alcoholic and ethereal solutions have an intensely bitter taste. By heating with various bases several santoninic acids are produced.

Action and Use.—Santonin is a pretty active substance, causing depression of the pulse, slowing of the breathing, trembling, sometimes severe tremors and convulsions, and in death. Pallor and cold sweats are also present. Most of the cases of poisoning by it have naturally been in children, and probably due to idiosyncrasy, as the doses were not very much larger than are frequently given. Yellow vision, in which all objects appear as if seen through a yellow glass, is a pathognomonic symptom of the absorption of santonin. It is a rather late-appearing phenomenon, and may last some days. Santonin is eliminated in alkaline combination in the urine, to which it also gives a deep orange color. It is not, however, with the hope of its physiological effects that either santonica or its active principle are given, but as a poison for intestinal worms, especially lumbrici. For this purpose it is an efficient one, on account of its comparative tastelessness and small bulk, a very convenient means, and is extensively employed, both by the profession and also in domestic practice, in the form of one or another of the popular "worm lozenges." The official troches of Santonin (Trochisci Santonini, U. S. Ph.) consist of one grain of santonin, a [illegible] of sugar, and half a grain of tragacanth each. One troche is a dose for a child five or six years of age. It is hardly safe to give santonin to very young children—two grains have caused death in one instance, and three or four grains have frequently produced dangerous symptoms in children.

Allied Plants.—Barbary wormseed is from another species of Artemisia. It is larger than Levant Wormseed, and [illegible] woolly. A. Absinthium is the Wormwood of the next article, and several other Artemisias are either called wormwoods or are used as such: [illegible]. They are all bitters like wormwood. For the order, see Chamomile.

Allied Drugs.—See Kousso.

W. P. Bolles.

WORMWOOD

WORMWOOD (*Absinthium*, U. S. Ph.; *Herba Absinthii*, Ph. G.; *Absinthe grande* ou *Aluyne*, Codex Med.).

Artemisia Absinthium Linn. Order, *Compositæ*. A European perennial, cultivated and naturalized in the United States. The [illegible] stems send up numerous slender, suffrutescent stems, about two feet high, with twice or thrice pinnate, silky, hoary leaves, and small panicles of nodding, hemispherical heads of yellowish flowers. Odor of crushed leaves, aromatic and fragrant; taste intensely bitter. The leaves and tops collected at the time of flowering are official. The Pharmacopœial description is as follows: "Leaves about [illegible] long, hoary, silky-pubescent, petiolate, roundish-triangular in outline, pinnately two or three cleft, with the segments lanceolate, the terminal one spatulate; heads [illegible] hemispherical, with numerous small, pale yellow florets, all tubular and without pappus; odor aromatic; taste persistently bitter."

The medicinal properties of wormwood are due to an essential oil of a dark green color, burning taste, and to some [illegible] of [illegible], and an incompletely crystalline neutral bitter principle, *Absinthin*. Wormwood has the [illegible] and aromatic properties that pervade many [illegible] in this great order, e.g., [illegible], chamomile, etc., and like them it is an agreeable stomachic. In large doses it is a disturber of the digestive apparatus and produces vomiting, diarrhœa, etc. It is also a convulsant of [illegible] power to [illegible] in use. It is not often prescribed at the present day by physicians.

Wormwood may be given in infusion like chamomile tea, or the essential oil may be given in small doses of from three to ten drops. It is an ingredient of a nearly obsolete liniment. [illegible] constitutes one per cent.

Allied Plants.—See Chamomile, and the preceding article.

Allied Drugs.—Most aromatic bitters.

W. P. Bolles.

WOUNDS, DRAINAGE OF.

WOUNDS, DRAINAGE OF. All wounds of healthy tissues are followed, after hemorrhage has been arrested, by an exudation of serous fluid varying in quantity according to the extent of the wound and the nature of the tissues injured. The amount and character of this fluid are also modified by extraneous circumstances, notably by the subsequent treatment of the wound. In subcutaneous and aseptic wounds, for example, the quantity is much less than in wounds which are not aseptic, where in the latter the clear serum soon becomes turbid, and is rapidly replaced by pus. On the other hand, wounds involving tissues which are already in a condition of inflammation are followed by a greater flow of serum, which in its turn is also more prone to become purulent; and finally, wounds involving tissues which are already in a state of suppuration are bathed in pus from the outset. All wounds, therefore, contain a fluid (serum or pus) which, if retained by the closure of the wound by sutures or otherwise, produces the surgical condition described as tension. Tension in its turn, by its gradually increasing pressure from within outward, produces venous and capillary stasis, pain from nerve pressure, fever, and other symptoms which warn the surgeon that all is not right. Briefly, the results which follow, proportionate to the amount and intensity of the condition—death of tissue, infection, suppuration, or perhaps merely reopening of the wound in whole or in part, but always more or less interference with the normal physiological process of repair. But when the wound secretions are allowed to flow off as rapidly as they form, a most important, if not the most important, aid to repair is thus secured. Hence arose the surgical law now almost universally adopted, that all wounds of any magnitude must be provided with drainage from the outset. Exceptions to this rule are subcutaneous wounds, superficial wounds which are allowed to remain open to heal by granulation, intra-peritoneal wounds when aseptic, wounds which are closed by buried sutures from the bottom by the [illegible], and sometimes wounds which are allowed to fill with an organizing blood-clot, as now recommended by Schede, of Hamburg.

Suppurating wounds are always drained. This, however, may be called secondary drainage, and differs entirely in its objects and results from the drainage of fresh aseptic wounds.

Materials Used for Securing Drainage.—Tubes of india-rubber, decalcified bone, glass, and metal, as well as skeins of silk, catgut, or horse-hair, are employed for this purpose. The introduction of india-rubber tubes into surgical practice is credited to Chassaignac, for although it seems tolerably clear that they had been used before his time in isolated cases, there is no doubt but that his practice and teaching were the causes of their general adoption. For a long time, however, their use was limited almost entirely, if not altogether, to suppurating wounds, and the next great impetus which the use of the drainage-tube received was from Lister, who in his antiseptic teachings showed that thorough drainage was an important factor in maintaining wounds in an aseptic condition. With the march of surgical progress, however, came the system of dry and infrequent dressing of wounds, and consequently an objection arose to the use of the rubber tube; for while a large wound could be healed under a single dressing, the sinuses left after the removal of the rubber tubes required further treatment. This led to the introduction of decalcified bone tubes for wound drainage. These are of two kinds: *a.* "Neuber's bone drains," introduced by Neuber, of Kiel, and prepared from beef bones by boring and turning with a lathe. They are then decalcified in a weak solution of hydrochloric acid, and preserved in an antiseptic solution. *b.* The long bones of fowls (chickens, turkeys, etc.), which are first boiled and scraped to remove the muscular and ligamentous attachments. They are next partially decalcified in a weak solution of hydrochloric acid, the articular ends cut off, and the periosteum removed by scraping. The contents of the medullary cavity with the endosteum must now be removed. This is easily done by detaching the endosteum at one end, and pushing the contents through with a small file, as in pithing a piece of green stem. Decalcification is then completed, and the bones are preserved in an antiseptic solution. The advantages of bone drains are that they are rapidly absorbed in wounds and require no removal, the sinus closing in upon the tube and healing as it is absorbed. The length of time required for the absorption of bone drains depends upon the size of the bone, and whether it has been completely decalcified or not. The writer has seen turkey-bone drains which were not completely absorbed at the end of six weeks in a wound of the knee-joint, and in other cases, in which a tube of the same size had been employed in a similar wound, complete absorption and healing of the wounds had occurred at the end of four weeks.

Choice of Tubes.—In ordinary aseptic operations or accidental wounds, bone drains are to be preferred for the reasons already given; but it must be borne in mind that, if for any reason drainage is likely to be required for a longer period than ten days or two weeks, the bone drain cannot be relied upon, as within the time mentioned it becomes so far absorbed as to collapse and become, therefore, inefficient or useless.

There is only one objection to the rubber drain, the necessity for its removal; otherwise it is the most reliable and the most universally applicable of all forms of drainage-tubes. Rubber tubing should, however, be thoroughly cleansed and preserved in an antiseptic solution for some time before being used. The use of the glass drain is practically limited to the drainage of the peritoneal cavity after abdominal operations—especially those upon the pelvic organs. Metallic tubes have been recommended for the drainage of wounds, but are seldom or never employed except for the drainage of the pleural cavity, where a tube of yielding material would soon become compressed between the ribs by the contraction of the chest-wall. A number of strands of catgut, silk, or horse-hair laid in the bottom of a wound, form a very efficient means of drainage for comparatively superficial wounds, and especially for wounds of the scalp, where a tube can usually only be retained with some difficulty and at the expense of some stretching of the sutures. It has been claimed that these substances secure drainage by capillary attraction, but it is very doubtful if this principle ever comes into operation under such circumstances. A number of threads or hairs placed in the bottom of a wound, simply form a conduit along which the wound secretions find their way by virtue of gravitation or pressure applied to the walls of the sinus or cavity. Fine catgut is by far the best material for such drainage, as it is rapidly absorbed, and is indeed the counterpart of the bone drain in larger wounds. Silk retains the secretions in its meshes, where they are liable to decompose and render the wound septic, and as it does not become absorbed, the dressings must be removed for its withdrawal. Horse-hair possesses the same disadvantages as silk, together with this extra one, that, owing to the imbricated arrangement of each hair, it is quite impossible to thoroughly cleanse it for use.

Influence of Dressings upon Drainage.—The dressings applied to wounds materially aid or interfere with their drainage. A properly applied dry dressing of soft absorbent material greatly facilitates drainage. But in the use of such dressings, if good judgment be not exercised, it is also possible to completely frustrate this end and prevent drainage. For example, in a small wound such as the operation-wound left after the amputation of a finger, or a moderately large scalp wound, the first serous discharges being moderate in quantity, are liable to dry up immediately over the face of the wound from contact with the dry material of the dressing and the dry air, and thus seal it up completely. It is necessary, therefore, in the great majority of wounds, to exclude the air from too direct contact with the discharges, either by the use of rubber cloth or gutta-percha tissue over the dressing, or in larger wounds by an external bandage of sized muslin, or muslin charged with plaster of Paris.

Drainage-tubes should always be introduced at the most dependent parts of the wound cavity, and a greater number of short tubes should be used in preference to a lesser number of long ones. The size, length, and number of tubes employed must be regulated by the extent of the wound and by other circumstances influencing the amount of secretion to be removed. In short, the removal of the fluid secretions of wounds must be conducted on ordinary hydraulic principles. For example, in the operation-wound left after the removal of a breast with the contents of the axilla, or after an amputation of the thigh, it is usually better to drain through incisions in the lower flap, when the original incision may be closed.

James Bell.

WOUNDS INCIDENT TO WARFARE. The consideration of wounds incident to warfare, aside from the practical view of treatment, affords an interesting and valuable study to the civil and military surgeon, especially when large numbers of wounds can be made available for the purpose.

In this article, it is proposed to make use of the large experience gained in the late civil war, and to present to the profession generally, in a succinct manner, the results attained from a careful study of the data collected by the Government, and presented at length in the third Surgical Volume of the Medical and Surgical History of the War of the Rebellion.

This material is generally illustrative of facts of general interest, and of statistical value, relating to wounds; of the nature, peculiarities, and effects of missiles and projectiles used in warfare; of the conditions affecting the course and result of wounds with especial reference to the graver complications of secondary hæmorrhage, erysipelas, pyæmia, gangrene, and tetanus, with a brief comparative reference to the subject of conservation, excision, and amputation.

During the late war there were treated 246,712 cases of wounds caused by weapons of war. Of these, 245,790 were shot wounds, and 992 were bayonet and sabre wounds.

Sabre and Bayonet Wounds.—In comparison with the large number of shot wounds, the number of sabre and bayonet wounds were insignificant, indicating the advance of modern military science in the general adoption of long-range repeating firearms, and showing that the sabre and bayonet are rapidly falling into disuse, and that the time is not far distant when these old and honored weapons will become obsolete, and when wounds from these sources will be regarded rather as incidents of warfare than as the results of regular tactical manœuvres.

Of the wounds of this nature grouped together in the following table a large proportion had their origin in private quarrels and brawls, or were inflicted by sentinels in the discharge of their duty.

Summary of Nine Hundred and Twenty-two Sabre and Bayonet Wounds Recorded during the American Civil War, 1861-65.

Seat of injury.	[illegible]	Sabre.					Bayonet.				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	22	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aggregates	922	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The fatality of these wounds, as indicated in the table, is small, perhaps exceedingly so, when it is considered that the injuries derive their importance from their tendency to excite inflammatory action in deep-seated tissues and cavities, with the danger of formation and confinement of pus, from the chances of injury to blood-vessels, nerves, and viscera, and from the possibility of pyæmia, gangrene, and tetanus.

As might be anticipated, wounds by the sabre involve, chiefly, such parts of the body as are especially exposed to blows in the ordinary use of this weapon; thus, injuries of the head and upper extremities are more largely represented, while wounds from the bayonet show a decided preponderance in the lower extremities.

Wounds from sabre blows were not of a grave character, except in cases involving the cranial cavity, where the mortality attained its highest percentage, though several cases were reported resulting in primary or secondary amputation.

Epilepsy, insanity, loss of vision and hearing, and impairment of the mental faculties, seem to have been among the remote effects of injuries to the cranium from this cause.

The fatality of bayonet wounds exceeds that of sabre wounds by 2.7 per cent., and is chiefly due to injuries of viscera and large blood-vessels.

The heart, lungs, diaphragm, liver, stomach, jejunum, and spleen are noted as having been punctured; and of the blood-vessels, the common iliac, femoral, internal pudic, and brachial were involved.

The fatal cases of bayonet wounds of the lower extremities resulted from gangrene in three cases, and from primary hæmorrhage and pyæmia in one instance each. The median and sciatic nerves were lacerated in two cases, and the psoas punctured in one. No case of tetanus is reported as following a bayonet wound.

Cavalry engagements were not common; in almost every case the cavalry was dismounted and fought as infantry with carbine and pistol.

The troops were almost entirely uninstructed in the use of the sabre, and this weapon was rarely sharpened.

Arrow Wounds.—During the prevalence of Indian hostilities on our frontier, in years past, arrow wounds were of frequent occurrence. Since the general adoption of firearms by all the tribes, and since the practical solution of the Indian question, they are rarely seen, but possess sufficient interest for passing remark.

The arrow used in warfare by savage Indians consists of a head and shaft. The former is roughly wrought by hand from schist, flint, obsidian, or iron, is from three-fourths of an inch to one inch and a half in length, triangular in shape, barbed at the inferior angles, acutely pointed and sharpened upon the edges. In later years thin hoop-iron, which is readily obtained and easily worked, has been generally substituted for other materials for arrow-heads, and makes a formidable missile. The head is fastened to the shaft by a neck, and secured in place by thongs of sinew or the tough filaments of the yucca plant, covered with gum or resin. The shaft is a wooden rod or cane, varying in length, notched at the end to admit the bow-string, and feathered for several inches from the notched end to secure steadiness and precision of flight.

The arrow, when thrown from a powerful bow, has a high initial velocity, and a force sufficient to pierce any animal tissue. Instances are cited of arrows passing entirely through the body of a man, or even of the larger animals. The collection of the Army Medical Museum, at Washington, D. C., contains specimens in which arrow-heads have perforated the thick dense ribs of a buffalo, and also the human cranial bones.

The effective range of an arrow is generally within seventy-five yards, but severe injuries may be caused at much greater distances. The Indian in warfare endeavors to bring his victim within the smallest range possible by ambush, or by creeping upon him stealthily.

Arrow wounds are punctured, lacerated, or incised, or may combine these several qualities.

When coming into contact with bony structure an arrow may penetrate or perforate; the injury to the bone may be a simple incision, as when a well-sharpened iron head is used; or it may be accompanied by fissuring, as when the blunter stone head is used, acting with wedge-like force.

Injuries to muscular tissue are generally in the form of deep penetrations, with more or less laceration. If the arrow glances, or penetrates at an oblique angle, the wound may show a cleanly cut incision, not unlike the cut or thrust of a small sword or dagger.

Arrow wounds are necessarily serious in their nature; copious hæmorrhage generally attends them: nerve-trunks are severed, and wounds of the internal organs are usually fatal; wounds involving bony structures are not uncommonly followed by periostitis, osteitis, and osteomyelitis; and even in muscular tissue, simple wounds are liable to result badly from inflammation, suppuration, and other surgical complications, owing to the fact that the arrow-head is easily detached from its shaft by the solvent action of the moist tissues upon the gum and resin attachments, and becomes a foreign body, difficult of extraction or removal.

There is a very common belief that poisoned arrows are used in Indian warfare. In one sense it is probable that this may be true. When war is determined upon, certain religious rites are observed, one of these being the preparation of the war arrows, by dipping them in a mixture of putrid animal offal, combined with the juices of certain plants considered to be death-bearing, and gathered from burial places and sacred soil. Wounds inflicted by arrows so prepared may excite severe inflammation, or even induce fatal septicæmia; but whether the use of absolute poison is common is doubtful. It is claimed that the poison of the rattlesnake is used for this purpose, but it is probable that only the putrid flesh of the reptile is employed, as above alluded to.

Spear Wounds.—Many of the Indian tribes formerly used spears in warfare. These weapons consisted of a blade of iron or sharpened flint, or obsidian, mounted on a staff; they are at present but little used. Wounds from this weapon differ but little in their character from bayonet, sabre, or sword wounds.

Shot Wounds.—The cases of shot wounds recorded during the war number 245,790. Undoubtedly this number falls far short of the actual truth. Lists and records of wounded are especially imperfect during the early part of the war, when each regiment, and often each detachment of troops, before the organization and establishment of base and general hospitals, continued to find shelter for its more seriously wounded men in tents or buildings temporarily occupied, which afforded no facilities for keeping records, and when both officers and men were allowed to proceed to their homes for treatment by their family physicians.

For convenience these wounds have been grouped in five tables, the first containing shot wounds of the head and face, the second of the neck, the third and fourth of the trunk, and the fifth those of the extremities.

Tabular Statement of the Shot Wounds of the Head and Face Recorded during the American Civil War.

Nature and seat of injury.	Totals.	Results.			Percentage of fatality.
		Recoveries.	Deaths.	Undeterm'd results.	
Shot injuries of the head:					
Flesh wounds of the scalp	7,759	4,865	162	2,712	3.2
Contusions of the bones of the skull	328	273	55	....	16.7
Fractures of the outer table	138	128	10	....	7.2
Fractures of the inner table	20	1	19	....	95.0
Fissures of the bones of the skull	19	12	7	....	36.7
Fractures without known depression	2,911	960	1,826	125	65.5
Fractures with depression	364	232	129	3	35.7
Penetrating fractures	486	84	402	....	82.7
Perforating fractures	73	17	56	....	76.7
Smash	9	....	9	...	100.0
Contre-coup	2	1	1	....	50.0
Total shot injuries of the head	12,089	6,573	2,676	2,840	28.9
Shot injuries of the face:					
Flesh wounds of the face	4,914	3,706	58	1,150	1.5
Fractures of the bones of the face	4,502	3,700	404	398	9.8
Total shot injuries of the face	9,416	7,406	462	1,548	5.8

Tabular Statement of the Shot Wounds of the Neck Recorded during the American Civil War.

Nature and seat of injury.	Totals.	Results.			Percentage of fatality.
		Recoveries.	Deaths.	Undeterm'd results.	
Shot injuries of the neck:					
Flesh wounds of the neck	4,789	3,450	570	769	14.1
Wounds injuring trachea	41	19	21	1	52.5
Wounds injuring larynx	30	10	10	10	50.0
Wounds injuring pharynx	13	5	7	1	58.3
Wounds injuring œsophagus	10	4	6	....	60.0
Wounds injuring trachea and larynx	4	4	....	....	....
Wounds injuring trachea and pharynx	2	2	....	....	....
Wounds injuring trachea and œsophagus	2	....	2	....	100.0
Wounds injuring larynx and œsophagus	1	1	....	....	....
Wounds injuring pharynx and œsophagus	1	1	....	....	....
Wounds injuring pharynx and larynx	2	...	2	....	100.0
Total shot injuries of the neck	4,895	3,496	618	781	15.0

Aside from flesh wounds of the scalp and hip, and slighter forms of contusion and fracture, shot wounds of the head were of very fatal character, the ratio of mortality following closely upon the degree of injury inflicted upon the brain and its appendages.

Fractures of the inner table of the cranial bones were of difficult diagnosis, and could in general be substantiated only after *post-mortem* inspection.

Perforating gave slightly more favorable results than penetrating fractures; this may have been due to the fact that less vital portions were involved, or that these wounds were more satisfactorily treated, being freed from the complications attending the lodgement of foreign bodies.

The results of shot injuries of the face confirm the opinion that these wounds commonly do well, notwithstanding the amount of destruction apparent at the time of injury.

The high mortality of shot wounds of the neck is almost necessarily to be expected from the lesions of these parts of great vital importance, placed in close relation with the great nervous and vascular trunks found in this region.

Tabular Statement of the Shot Wounds of the Spine and Chest Recorded during the American Civil War.

Nature and seat of injury.	Totals.	Results.			Percentage of fatality.
		Recoveries.	Deaths.	Undetermined results.	
Shot wounds of the spine:					
Fractures of cervical vertebræ	91	27	63	1	70.0
Fractures of dorsal vertebræ	137	50	87	....	63.5
Fractures of lumbar vertebræ	149	79	66	4	45.5
Fractures of cervical and dorsal vertebræ	2	1	1	....	50.0
Fractures of dorsal and lumbar vertebræ	3	....	3	....	100.0
Fractures of vertebræ, region not stated	260	122	129	9	51.3
Total shot injuries of the spine	642	279	349	14	55.5
Shot wounds of the chest:					
Flesh wounds of the chest	11,549	10,778	113	658	1.0
Fractures of ribs	446	362	68	16	15.8
Penetrations of the cavity of the chest	8,269	2,781	5,192	296	65.1
Total shot injuries of the chest	20,264	13,921	5,373	970	27.8

Tabular Statement of the Shot Wounds of the Abdomen, Pelvis, and Back, Recorded during the American Civil War.

Nature and seat of injury.	Cases.	Results.			Percentage of fatality.
		Recovered.	Died.	Result undetermined.	
Shot wounds of the abdomen:					
Flesh wounds of the parietes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Contusions of the abdomen	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	41	31	9		[illegible]
Penetrating wounds without visceral injury	[illegible]	12	[illegible]		[illegible]
Wounds of the stomach	[illegible]	[illegible]	[illegible]		[illegible]
Wounds of the intestines	[illegible]	[illegible]	[illegible]	51	[illegible]
Wounds of the liver	[illegible]	[illegible]	[illegible]	9	[illegible]
Wounds of the spleen	[illegible]	[illegible]	[illegible]		[illegible]
Wounds of the pancreas	[illegible]	[illegible]	1		[illegible]
Wounds of the kidney	[illegible]	[illegible]	[illegible]	1	[illegible]
[illegible]	54	7	[illegible]		[illegible]
[illegible]	1		1		100.0
[illegible]	[illegible]	[illegible]	[illegible]	187	[illegible]
Total shot injuries of the abdomen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shot wounds of the pelvis:					
Fractures of the bones of the pelvis	[illegible]	[illegible]	[illegible]	32	[illegible]
[illegible]	[illegible]	25	11		[illegible]
Wounds of the bladder	[illegible]	[illegible]	[illegible]		[illegible]
Wounds of the prostate	[illegible]	1	1		[illegible]
Wounds of the rectum	[illegible]	[illegible]	44		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Wounds of the penis	[illegible]	[illegible]	11		[illegible]
Wounds of the scrotum	[illegible]	[illegible]	22		[illegible]
Wounds of the testes	[illegible]	[illegible]	[illegible]		11.2
Wounds of the spermatic cord	[illegible]	[illegible]	2		[illegible]
Wounds of the genital organs, [illegible]	[illegible]	[illegible]	[illegible]	1	11.1
Total shot injuries of the pelvis	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shot wounds of the back:					
Reported as shot wounds of the back	[illegible]	[illegible]	172	[illegible]	5.3
Specified as over the posterior thoracic region	[illegible]	[illegible]	[illegible]	[illegible]	5.4
Specified as over the posterior abdominal region	[illegible]	620	[illegible]	27	[illegible]
[illegible]	[illegible]	[illegible]	526	[illegible]	[illegible]
Total shot injuries of the back	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The great fatality of unqualified shot penetrations of the abdomen is apparent in the preceding table; of the [illegible] determined instances of such lesions, [illegible] had a fatal termination, a mortality rate of [illegible] per cent, exceeding that of the shot fractures of the cranium with penetration of the brain, which was [illegible] per cent. Even the large fatality of shot fractures of the hip, [illegible] per cent, in the succeeding table, is in some measure due to complications with injuries of the viscera of the abdominal cavity.

With two exceptions, the generally accepted rule in fractures of the extremities, that the ratio of fatality diminishes with increased distance of the injury from the trunk, is verified in the table.

In the upper extremities the fractures of the wrist had a greater fatality than those of the forearm (12.9 and 9.4 per cent, respectively); and in the lower extremities the results of injuries of the knee joint were slightly less favorable than those of the femur, the mortality rate being 53.8 per cent in the former and 53.1 in the latter, although the difference, 0.7 per cent, is very trifling.

Although the wounds of the joints indicate injuries of a more serious nature than those of the long bones immediately above them, the percentages of fatality do not seem to have been proportionally increased.

But wounds of the joints were more frequently followed by excision and amputation, and it would seem, therefore, that the increased ratio of operations had tended to reduce the percentage of fatality.

Measurements of the Pythian Apollo and Farnesian Hercules cited by Longmore in his work on gunshot injuries, as to the relative amounts of superficial area presented by the principal divisions of the human body, give as a mean the following percentage of the whole target area of the body: for the head, face, and neck, 8.51 per cent; for the trunk, 28.91; for the upper extremities, 21.14; for the lower extremities, 41.41 per cent.

If battles were fought and decided on level and unobstructed ground we might find that the percentages of the injuries inflicted on the various sections of the human body would correspond with the proportional percentage of the area; but it is evident that the nature of the field of operations, whether fortified places or the open plain, or rolling wooded districts, must necessarily affect the relative regional frequency of injuries.

Tabular Statement of Shot Wounds of the Upper and Lower Extremities Recorded during the American Civil War.

Nature and seat of injury.	Cases.	Results.			Percentage of fatality.
		Recovered.	Fatal.	Result undetermined.	
Shot wounds of the upper extremities:					
Flesh wounds of the upper extremities	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]—excision.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total shot wounds of upper extremities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shot wounds of the lower extremities:					
Flesh wounds of the lower extremities	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]		[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total shot wounds of lower extremities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Of the wounds treated in the late civil war, as shown by the following table, 10.77 per cent. were injuries of the head, face, and neck; 18.37 of the trunk; 37.71 of the upper extremities, and 35.15 of the lower extremities.

Table indicating Percentage of Fatality and Relative Frequency of Shot Wounds Recorded during the War of the Rebellion.

Seat of injury.	Total cases.	Results.			Percentage of fatality.	Relative frequency.	
		Recoveries.	Deaths.	Undetermined results.			
Shot injuries of the head	12,089	6,573	2,676	2,840	28.9		14.91
Shot injuries of the face	9,416	7,406	462	1,548	5.8	10.77	3.87
Shot injuries of the neck	4,895	3,196	618	781	15.0		1.99
Shot injuries of the spine	642	279	349	14	55.5		0.26
Shot injuries of the chest	20,264	13,921	5,373	970	27.8		8.24
Shot injuries of the abdomen	8,438	3,455	3,293	1,690	48.7	18.37	3.43
Shot injuries of the pelvis	3,159	2,194	930	35	29.7		1.28
Shot flesh wounds of the back	12,681	10,883	800	998	6.9		5.16
Shot injuries of the upper extremities	87,793	80,090	5,608	2,095	6.5		35.71
Shot injuries of the lower extremities	86,413	73,665	11,813	935	13.8		35.15
Aggregates	245,790	201,962	31,922	11,906	13.6		00.00

According to this tabular statement, the injuries of the extremities form 70.86 per cent. of the total number of wounds, and the proportion of the wounds of these parts would therefore appear disproportionally large.

But it must be borne in mind that these figures constitute only a portion of the injuries received, as the large number of killed are not included in these calculations.

According to the report of the Adjutant-General of the Army, the total number of killed was not less than 44,238.

The records of the Surgeon-General's office give the seat of injury in only 1,173 cases of soldiers killed on the battle-field. Of these, 487 were of the head and neck, 603 of the trunk, 30 of the upper extremities, and 53 of the lower extremities.

Applying the above proportions of the 1,173 cases to the total of 44,238 killed, we would have 18,367 killed from injuries of the head, 22,741 from wounds of the trunk, 1,131 from wounds of the upper extremities, and 1,999 from casualties of the lower extremities.

Adding to these the cases of wounded according to the above table, viz., 26,400 of the head, 45,184 of the trunk, 87,793 of the upper extremities, and 86,413 of the lower extremities, we have a total of injuries, according to regions of the body, including killed and wounded, of 44,767 head, 67,925 trunk, 88,924 upper extremities, and 88,412 lower extremities; or, according to percentages, 15.44 per cent. injuries of the head, 23.42 per cent. injuries of the trunk, 30.66 per cent. injuries of the upper extremities, and 30.48 per cent. injuries of the lower extremities, making a total of 61.14 per cent. of injuries of the extremities.

Whether we take into consideration the percentage of the injuries of the upper extremities derived from the total number of wounded and killed, 30.66 per cent., or that obtained from the number of soldiers treated for wounds only, 35.71 per cent., the regional proportion of these injuries is very large.

But the protection afforded to the lower extremities and the trunk in the many siege operations, by parapets, and in the field by trenches, ditches, trees, etc., saved these parts largely from injury, while the head and upper extremities were continually exposed to the practised eye of a vigilant foe.

The percentage of regional injuries, compiled from the most reliable accounts of European and other campaigns is illustrated in the following table, and closely approximates the percentage derived from a study of the injuries of the American civil war.

Tabular Statement of the Relative Frequency of Shot Wounds of the Different Regions of the Body.

Occasions and authorities.	Cases.	Head, face, and neck.		Trunk.		Upper extremities.		Lower extremities.	
		Cases.	Percentage.	Cases.	Percentage.	Cases.	Percentage.	Cases.	Percentage.
Revolution in Paris, 1830 (Ménière, Jobert de Lamballe)	627	40	6.4	117	18 7	193	30.8	277	44.1
Revolution in Paris, 1848 (Baudens, Huguier, Jobert de Lamballe).	413	46	11.1	77	18.7	116	28.1	174	42.1
Schleswig-Holstein War, 1848–51 (Simon Djörup)	6,355	949	14.9	1,006	15.8	1,804	28.4	2,596	40.9
Crimean War, 1854–57, English (Matthew)	9,971	2,000	20.1	1,500	15.0	3,089	31 0	3,382	33.9
Crimean War, 1854–57, French (Chenu)	25,993	5,263	20 2	4,937	19.0	8,238	31 7	7,555	29 1
Campaign in the Kabylie, 1854-57 (Bertherand)	1,422	220	15.5	249	17.5	267	18.8	686	48 2
Mutiny in India, 1858 59 (Williamson)	558	60	10.8	52	9.3	212	38.0	234	41.9
Campaign in Italy, 1859, Austrian (Demme)	17,095	2,050	12.0	3,750	21.9	6,047	35 4	5,248	30 7
Campaign in Italy, 1859, French (Chenu)	15,401	1.514	9 8	2,265	14.7	5,378	34 9	6,244	40.6
Campaign in New Zealand, 1863-65 (Mouat)	48	8	16.7	15	31.2	12	25.0	13	27.1
French in Mexico, 1864 (Bintot)	66	11	16.7	10	15.1	20	30.3	25	37.9
Schleswig-Holstein War, 1864 (Loeffler)	3,171	458	14.4	614	19.4	925	29 2	1,174	37.0
Austro-Prussian War, 1866, Germans (Maas, Biefel, Stromeyer, Beck)	2.282	218	9.5	410	18.0	591	25 9	1,063	46 6
Austro-Prussian War, 1866, Italians (Cortese)	2,811	333	11.8	529	18.8	761	27.1	1,188	42.3
Revolt in Montenegro, 1869 (Riedl and Ebner)	108	17	15.8	16	14.8	40	37.0	35	32 4
United States Army, 1865–70 (Otis)	387	83	21 4	145	37 5	79	20 4	80	20.7
Franco-German War, 1870–71, Prussians (Fischer)	53,482	7,880	14 7	8,835	16 5	17.795	33 3	18,972	35 5
Franco-German War, 1870–71, Bavarians (Beck)	4.344	611	14.1	772	17.8	1.174	27.0	1,787	41.1
Franco-German War, 1870–71, French (Chenu)	71,443	9,376	13.1	20,243	28 4	19,588	27.4	22,236	31 1
Russo-Turkish War, 1876–77 (Tiling, Kade)	371	47	12 7	41	11.1	146	39 3	137	36 9
Totals	216,348	31,184	14.4	45,583	21.1	66.475	30 7	73,106	33.8
War of the Rebellion in the United States of America, 1861–65.	245,739	26.400	10.7	45.184	18.4	87,793	35.7	86,413	35.1
Aggregates	462,087	57,584	12.5	90,767	19 6	154,268	33 3	159 519	34.5

The excessively large percentage of wounds of the hands and fingers, frequently noticed by writers on military surgery, was also observed in the late war.

It is possible that this large percentage is due to the increased exposure of the hand from constant movement over a considerable area, thus increasing the chances of intercepting missiles in their flight.

Definition of Shot Injuries.—All injuries caused directly or indirectly by missiles and projectiles, impelled by the force of gunpowder or other explosive, have been included in the term "shot" injuries.

They differ from the accidents common to ordinary life, not so much in their essential character, as in the peculiarities of the conditions and circumstances attending them, and on this account invite especial attention to the producing causes, to the dangers and complications liable to arise in their course, and to their management and treatment under conditions generally

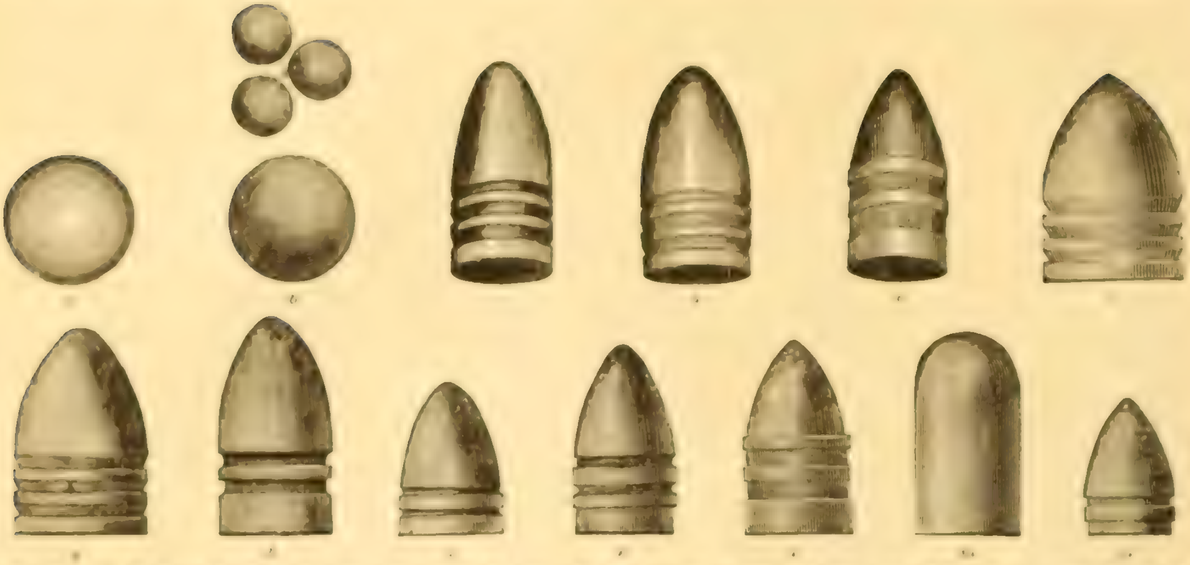

FIG. 4624.—a, U. S. round musket-ball, calibre .69, weight 412 grains; b, buck and ball cartridge, [illegible]

less favorable than are found in the practice of civil surgery.

A gunshot wound is essentially a contused wound, yet the character of the missile and the circumstances surrounding the individual at the time of injury may impose upon it the additional features belonging to incised, lacerated, and penetrating wounds.

In degree it may range from trivial simplicity to all the terrible gravity of injuries seen upon the battle-field; yet in all its phases, simple or complicated, the application of the sound principles of general surgery forms the basis of treatment and marks the advance of surgical science in the present day.

The great superiority of the rifled arm and cylindro-conoidal projectile as compared with the smooth-bore musket and round ball, had been fully established by the experience of foreign nations in the great wars of Europe between the years 1848 and 1860, and had opened to the military surgeon an interesting field of inquiry regarding the modification of the nature of wounds resulting from the use of the improved firearms.

FIREARMS AND THEIR PROJECTILES.—Projectiles common in warfare may be divided into those used with small arms, as rifles, muskets, pistols, etc.; those discharged from heavy ordnance, as cannon, both rifled and smooth-bore, mortars, torpedoes, etc.; those which act indirectly in the causation of injury, as splinters, stones, and fragments detached or set in motion by projectiles in their flight; and missiles of an unusual or eccentric character. By far the greater number of shot injuries in warfare are inflicted by missiles from small arms.

In the late war the nature of the missile was ascertained in [illegible] cases, of which [illegible], or [illegible] per cent., were caused by missiles from small arms.

The projectiles or missiles used with small arms are either spherical balls, usually discharged from smooth-bore muskets, or those of an elongated form adapted to rifled arms; the latter are conical, cylindro-conoidal, or ovoid, varying in size, weight, and volume.

The material composing small-arm missiles is usually lead hardened by an alloy of tin or antimony.

The superiority of the elongated missile thrown from the rifled barrel over the spherical ball, rests upon the fact that the elongated bullets have usually an expansive base, [illegible] which by the explosion of the charge is intended to fill the grooves of the rifle, and give the projectile, as it is driven forward, rotation on its long axis, thus increasing its range and precision.

The cuts appended (Fig. 4624) are designed to illustrate the general appearance of the more common and typical varieties of small-arm missiles used during the late war by both parties.

The large projectiles used with ordnance may also be classified under the headings spherical and elongated, the former being generally used with smooth-bore, the latter with rifled guns.

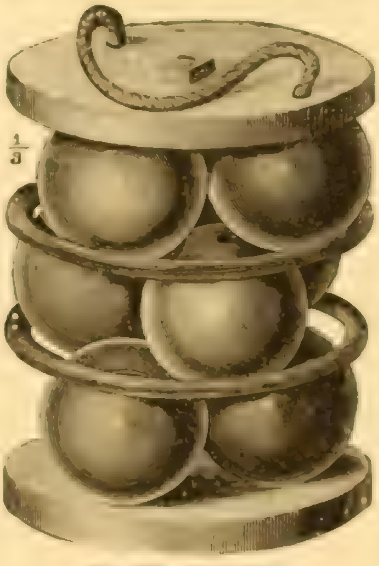

FIG. 4625.—Grape-shot.[1]

Round shot are solid spheres of cast iron varying in weight and size.

A grape-shot (Fig. 4625) is composed of a number of cast-iron balls (in the U. S. service generally nine) arranged in layers of three each, and kept together by a central rod secured by nuts on each end. These missiles vary in calibre to fit guns of different sizes. Upon discharge the several parts become separated, and each part acts as a distinct projectile. They have considerable range.

A canister shot is a projectile made by enclosing a large number of iron or leaden balls, of less size than grape, in a cylinder of tin, which is torn asunder at the discharge of the gun; the contents are scattered, assuming in their onward course something of the area and shape of a cone. When used against bodies of troops and at short range, the canister shot is very destructive.

Shrapnel-shots are spherical or elongated, according to the character of the gun in which they are used, and when adapted to smooth bores they are designated spherical case-shot. They are shells of considerable thickness, filled with musket-balls consolidated into mass by a composition of resin and sulphur, and are exploded by a charge of powder fitted into their interior, which is ignited by a time or percussion fuse. (Figs. 4626, 4627, and 4628.)

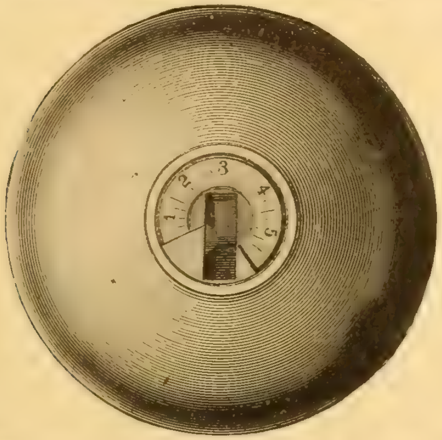

FIG. 4626.—A Twelve-pound Spherical Case-shot, outer and upper view.[1]

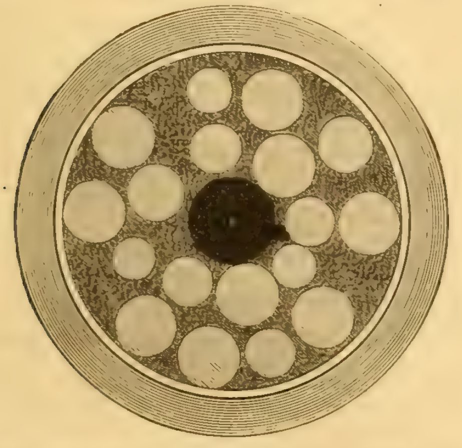

FIG. 4627.—The Same Sawn in Half, Showing the Bullets and Composition.[1]

They have a long effective range and are calculated to inflict serious injury by the great number of fragments set loose at their explosion.

The projectiles used in rifled guns exclusively, combine with the properties and character of the projectiles just described those which pertain particularly to guns constructed on the rifled principle; they vary greatly in size and weight; their velocity varies with the calibre from 1,100 to 1,550 feet per second, and in more recent guns a much higher velocity has been obtained, as well as increased power and range.

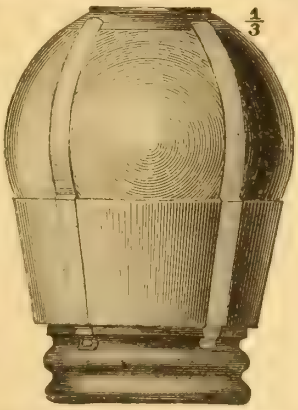

FIG. 4628.—A Spherical Case-shot Strapped for Howitzer or Gun.[1]

The ten-pounder percussion Parrott case-shot, much used in the late war (Fig. 4629), is a missile of this nature.

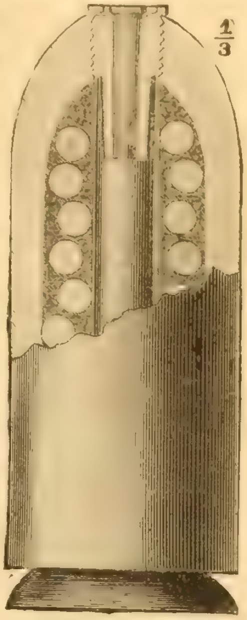

FIG. 4629.—A Ten-pound Percussion Parrott Case-shot.[1]

By the explosion the shell is rent into many fragments, small and large; these fragments are driven in all directions with great force, and inflict injuries of the gravest character.

Rifled projectiles are also cast solid, and are used for breaching or battering purposes.

Bolts, so called, are solid metal projectiles of elongated form, with surfaces cut to fit corresponding surfaces in the barrel of the gun; they are made to fit with great exactness, so that a greater proportional effect is attained with a smaller charge of explosive.

The Whitworth projectile, used to some extent in the late war, may be taken as a type of this class.

Shells thrown from mortars differ little, if any, from ordinary spherical shells, except in size and in the manner of projection. Their use is generally restricted to siege purposes. Solid shot heated in furnaces designed for the purpose, are sometimes used in warfare, but with the intent of destroying property rather than human life.

Hand-grenades are small iron shells filled with powder and discharged by percussion; they are commonly used in sieges and assaults at close quarters; injuries result from the fragments of the exploded shell. As their name indicates, they are thrown by hand.

Torpedoes were largely used during the late war as a means of defence, and were commonly large shells arranged with levers connecting with a percussion fuse. They were sunk below the level of the earth and concealed by dirt and brush. The pressure of the foot was sufficient to explode them, with effects similar to the bursting of a like projectile under ordinary circumstances.

In a third division of missiles and projectiles are included such as cause wounds and injuries indirectly; splinters, stones, foreign bodies set in motion or driven by the force of projectiles in their course, and which, by their action or lodgement frequently complicate direct shot wounds, and are themselves sources of danger.

The most common examples of this class are fragments of stone and splinters of wood, torn from the earth or from trees, and structures forming defensive works, scraps of iron or metal from ordnance, firearms, or from articles of equipment; or indeed from any object with which a projectile may come in contact.

The ordinary "buck and ball," a compound missile, was extensively used in the earlier years of the war; it consisted simply of the ordinary round ball, calibre .69, and three buck-shot enclosed in the same cartridge. These missiles were very effective at close range.

Slugs and fowling-piece ammunition were not infrequently used.

The subject of the employment of explosive bullets in small arms in warfare between civilized nations has been largely discussed from an ethical point of view, particularly since the civil war in the United States. While their use is acknowledged to savor of barbaric warfare, there is still a manifest reluctance to place them entirely beyond the pale of legitimate employment.

One hundred and thirty cases of wounds attributed to explosive bullets were recorded among the casualties of the late war; the injury from these missiles is greater and more severe than that from a simple ball; bony structones are more extensively shattered, and the area of destruction of soft parts is larger; hæmorrhage, both primary and secondary, is more common; extensive sloughing follows, and the course of repair is slow and tedious.

The Gardner explosive bullet or "musket-shell" (Fig. 4630), used in the civil war, is a cylindro-conoidal projectile of lead, made in two sizes—the larger of calibre .58, weighing 451 grains, the smaller of calibre .54, weighing 363 grains. Within the interior is placed an accurately-fitting cup-shaped chamber filled with percussion powder, and communicating with a time-fuse which is exposed to the charge at the rear of the missile; the fuse is ignited by the discharge of the piece. The bursting charge is sufficient to rend the bullet and transform it into a dangerous jagged missile. Should it have penetrated the body before exploding, its effects are most disastrous. It is claimed that other forms of projectiles of this nature were used, provided with percussion caps intended to explode upon contact with even soft tissues.

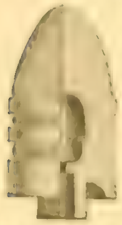

FIG. 4630.—Gardner's Explosive Ball.

Surgeon H. R. Tilton, U. S. Army, mentions in correspondence upon this subject the fact that explosive bullets were found among ammunition captured from the Nez Percés Indians during the late war with that tribe.

The appearance of an exploded musket-shell extracted from the thigh of a soldier is shown in Fig. 4631. The wound resulting was a flesh wound of the muscles of the thigh, and the bullet was removed by enlarging the opening of entrance.

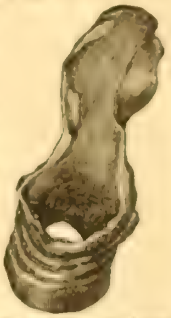

FIG. 4631.—Exploded Bullet Extracted from Thigh.

EFFECTS OF LARGE PROJECTILES.—The injuries caused by large projectiles depend upon their weight, size, and momentum. At high velocities they virtually encounter no resistance from a single human body, and their force is but slowly expended on masses of soldiery. Their form is of little importance, as similar results follow the use of spherical and elongated shot and shells; their impact is followed by instant death or by wounds of great severity.

When the injury is not immediately fatal, as when a limb is carried away by a projectile of considerable size striking directly, the surface of the stump will be found to be somewhat cleanly cut, the skin and muscular tissue contused and dark, with little retraction; the bone fractured with not much splintering or comminution above the seat of injury; the arteries retracted, and the hæmorrhage generally slight.

If the projectile strikes obliquely and with diminished force, the resulting wound shows a deeply grooved furrow, corresponding to the size of the projectile and influenced by its direction; the skin, fascia, and soft parts are extensively contused and lacerated, or removed entirely; the surface is covered with blood-clots and shreds of connective, muscular, and areolar tissue; arteries and nerves are often seen stretched and hanging in the open wound. Hæmorrhage is commonly slight or ceases after a first gush.

If the projectile penetrates cavities, disorganization and destruction of parts will follow, resulting in death, either immediately or in a very short time.

A solid shot whose velocity is so greatly diminished as to seem harmless is still capable of doing great damage through its acquired momentum. It may not possess the force necessary to carry away any part of the body, but a contusion or wound resulting from its impact is generally serious, and not infrequently fatal.

It may be that no outward evidences of injury are manifest beyond some discoloration, but subsequent symptoms indicate the existence of grave internal lesions; rupture of the viscera, concussion of the brain or spinal cord, and often fractures of bones with extensive comminution and disorganization of the surrounding soft parts.

Slighter contusions generally impair or destroy the vitality of the skin and soft parts, and result in extensive sloughing and in slow repair.

The occurrence of simple fracture and dislocation are sometimes noticed, but are infrequent.

Probably the largest class of injuries attributable to heavy projectiles is that resulting from fragments of exploded shell.

The character of these wounds depends largely upon the weight, form, and velocity of the fragments. Pieces of great weight and size, moving with high velocity, inflict wounds similar to, and not less severe than, those caused by the larger projectiles already mentioned. As their velocity diminishes, which is rapidly the case, owing to the great resistance offered by the air to the passage of irregularly shaped bodies, as well as to gravitation and modification of the original impetus, the factor of weight alone assumes importance, as even with slow motion the momentum of such masses is almost irresistible.

The form of the projectile may determine the severity of a wound, especially when the fragment is of small size, the sharply outlined edges becoming sources of danger to blood-vessels, nerves, and viscera.

Wounds from large shell fragments are attended with great laceration and destruction.

When the force is insufficient to carry away a portion of the trunk or an extremity, the resulting wound is deeply contused, with jagged and irregular edges; there may be a loss of more or less of substance; bony structures exposed to the force of a blow are shattered and comminuted; not infrequently the fragment will be found lodged in the wound.

In some cases a large fragment will pierce the skin without destroying its vitality, and sink deep into the cavities or soft parts, the skin retracting so as to present so small an opening as to obscure the diagnosis, until subsequent symptoms disclose the true nature of the injury.

As in cases of solid shot, contusions of little or no outward significance beyond apparently slight bruising, but attended with extreme internal disorganization, are frequently met with.

A curious case of lodgement may be referred to as occurring during the late war, in the case of a soldier from whose left gluteal region an operating surgeon removed a twelve-pound round shell, the patient surviving the injury some forty-eight hours. The missile was entirely concealed behind the gluteal muscles.

Wounds from grape-shot partake of the general nature of injuries from cannon-balls. The velocity of these projectiles is, however, generally lower and their weight less, so that their destructive power is somewhat limited.

Case and canister shot, as well as small fragments of shell, produce effects not materially differing from those of small-arm missiles.

The effects resulting from the explosion of torpedoes, though somewhat dependent upon their size, nature, and proximity, are extremely terrible.

Not only is the violent action of fragments, splinters, stones, and foreign bodies, hurled at great velocity, to be considered, but also the consequences of exposure to the flame and gas of the exploding charge. Should life be not immediately extinguished, fearful mangling and mutilation result, while the presence of burns and the effects of the inhalation of heated gases serve to complicate the condition.

Although the reports of alleged effects from the "wind of balls" do not seem to merit serious consideration, it would appear, by the number of reports of cases of this character during the war, that there is still a lingering belief that injuries from this source are not of infrequent occurrence.

After a careful examination and consideration of these reports, the evidence unmistakably points to effects produced by actual contact of the missile, causing severe concussion, or to the accident known as the "brush of a ball," in which the missile passes so near as to actually touch the clothing or skin without tearing the one or the other, yet producing severe results, among which may be cited swelling, inflammation, and sloughing, and even paralysis.

The several theories of vacuum, of foreign bodies carried along with the ball, and of electricity, which have, from time to time, been suggested to support the idea of injuries from the "windage" of balls, have all been disproved, and it is now conceded by modern surgeons that, without actual contact of a projectile, injuries cannot occur; but it is admitted that slight contact from the "grazing" or "brushing" of a projectile, or the rolling motion of a cannon-ball over the surface of the body, may, by weight and momentum, aided by the elasticity of the skin, effect most serious results, while little or no external evidence of such contact is left.

Instances of injuries attributable to the explosion of shells near at hand, without wound or contusion, are numerous and generally well authenticated. They are for the most part cases of partial or complete paralysis, deafness, blindness, loss of voice, rupture of superficial vessels, and mental prostration.

The proportion of cases of deafness among artillery officers and cannoniers has been, since the late war, a frequent subject of remark, and the frequency of rupture of the membrane of the tympanum from propinquity to artillery fire has been specially noted.

EFFECTS OF MISSILES AND PROJECTILES FROM SMALL ARMS.—In the great aggregate of shot wounds reported during the civil war, by far the greatest number was due to missiles from small arms.

In considering the effects of large projectiles, size, weight, and velocity constituted the principal factors; in the case of missiles from small arms, form, both original and that acquired by accidental causes, assumes importance, as well as the relation of the individual injured to the impinging projectile, the direction of the ball, position, structure, and power of resistance of the parts, and the course of the missile through the tissues.

With reference to the projectile itself, form and velocity are of principal importance; size, weight, and volume modify the character and extent of the wound, while the remaining factors have an especial subjective relation.

Aside from the influence which the improvements in modern small arms may have had in increasing the general effectiveness of projectiles, the adaptation of the conoidal missile to the rifled barrel has unquestionably wrought a change in the surgical relations of wounds, the opinion being generally expressed by surgeons that wounds caused by elongated missiles are more severe and dangerous than those resulting from spherical balls.

The cylindro-conoidal missile attains a great range with effective power, it opposes less frontage to the resistance of the air, and its velocity suffers more gradual retardation than that of a round ball.

Rotation upon its long axis tends to give it a steadier flight and a more direct course.

Its pointed apex, aided by its rotation, gives it the mechanical advantages of the wedge and screw, enabling it to pierce more easily the structure of opposing bodies, while it suffers a proportionally less diminution of force; adding the factor velocity, we have a missile endued with tremendous force, maintaining for a long time and over great distances a steady flight, not easily deflected, piercing and rending opposing obstacles, and preserving, even at immense range, a momentum sufficient to render it deadly in its effects.

It is probably true that at very close quarters the effects of the round ball are hardly less destructive than those of the elongated missile; but, as the peculiar power of the rifled bullet mainly lies in its destructive effects at long range, the change of military tactics based upon this fact has compelled the general use of weapons of greater power, and has lessened the opportunities for comparison on any extended scale.

The size and weight of small-arm missiles vary within such narrow limits as to make practically but little difference in the effects produced by them; though in the question of the extraction of a ball between bones or joints, dimension may be of importance, as well as in the consideration of the gravity of penetrating wounds of the chest.

Missiles from carbines, pistols, and fowling-pieces, when used as weapons of war, produce injuries very analogous to those of the ordinarily used small arms, but being of smaller size and impelled with less force, their wounding power is generally less.

Even the small buck-shot, one of the constituents of the "buck and ball," have sufficient force to place one or more men, temporarily at least, *hors de combat*.

The accidental forms and distortions which leaden projectiles are liable to assume by contact with opposing obstacles, both within and without the body, form a curious and interesting feature in the study of missiles and their effects. These distortions are of all imaginable forms, and their course through the tissues is frequently no less erratic.

ENTRANCE AND EXIT WOUNDS.—Small missiles impinging upon the human body and penetrating the skin, inflict what is known as the wound of entrance; if preserving sufficient force to perforate, the opening last made is called the wound of exit.

Wounds of entrance and exit have for years been the subject of lengthy discussion by surgical writers, and are supposed to possess certain diagnostic value, as indicating in a general way the form and variety of missile, its velocity, its probable course through tissues, and, to some extent, the nature and character of the wound.

Under the force of ever-varying conditions, they are very diverse in appearances and extent, and their significance is largely dependent upon the experience and acuteness of the observer.

In general, a bullet preserving its integrity, impinging at ordinary range and at a right angle upon a portion of the body well covered with soft tissue, and not unnaturally put upon the stretch, leaves, as it passes through the skin, an opening more or less regularly rounded in form, often perhaps a little less in diameter than the missile, with the edges inverted and livid in hue, due partly to the contusion and partly to the discoloration from the burned powder carried upon the missile. In the case of a spherical ball there is usually some loss of substance, a portion of the integument being carried away before its obtuse surface. A cylindro-conoidal missile will generally cause a more irregularly outlined opening, either stellate or slit-like, with serrated or ragged edges.

The wound of exit may closely resemble that of entrance, but is commonly larger and more irregular, with everted edges, bearing fewer evidences of contusion, but often showing a greater loss of substance.

From these simple, uncomplicated forms of wound we find an almost infinite variation, dependent upon the peculiar circumstances which impress their characteristics upon each case.

If the missile has carried before it a foreign body, or has become distorted, or has suffered a diminution of velocity and force, the wound of entrance will be modified accordingly, showing greater irregularity of outline, and presenting greater laceration of tissue.

The resistance offered by the tissues to the passage of a missile through any part of the body, will largely influence the character of both entrance and exit wounds.

Obliquity of the course of a missile to the plane of the surface of the body may result in merely a superficial grazing or furrowing, or in penetration and perforation; in which cases the appearance of the wounds of entrance and exit will depend on the angle of impact.

Fragments of shell produce irregularly-shaped wounds, with contusion and considerable loss of substance; should their force be sufficient to perforate a part, the wound of exit is lacerated and ragged, with portions of muscular and connective tissue thrust out of the opening.

The differential diagnosis between these and bullet wounds is usually not difficult.

A single wound of entrance may have two or more wounds of exit; as, for example, when a missile is divided upon a bone.

A bullet may be split into fragments before striking the body, in which case the fragments may each enter and leave separately, or one or more of the fragments may lodge.

Multiple wounds of entrance and exit are common, resulting from a missile perforating two or more parts of the body successively, as two arms, two legs, the body and one or more extremities, or parts of the same extremity when flexed. Cases are recorded in which the missile has entered and made its exit by the same opening.

EFFECTS OF MISSILES ON MUSCULAR TISSUE AND FASCIÆ.—The differences of structure and density of the muscular and tendinous tissues of the body, encountered by a bullet in its passage, are found to influence the direction of its course, unless the velocity, and consequently the momentum, is sufficiently great to overcome the resistance offered, as in the case of a conoidal ball at high velocity, the course of which is generally direct.

Round balls presenting an obtuse frontage part more easily with their force, and are readily deflected by fasciæ and aponeurotic expansions, pursuing curious and devious courses until they either find exit or make lodgement.

The effects of missiles of different character upon muscular structure are not dissimilar; the track of a small conoidal bullet passing swiftly through a muscle is generally more cleanly cut than that made by a large or round ball; but in all shot wounds there is usually found an irregular channel, with contused and lacerated walls, more or less devitalized by contact with the missile, the area of injury gradually shading off by concentric layers until lost in healthy tissue.

There is always more or less loss of substance dependent somewhat on muscular tension and relaxation, also upon the rotation of the missile in its passage, whether upon its long or short axis.

Fasciæ and aponeurotic tissue are torn and lacerated, or simply perforated, according to their condition of tension at the time; their openings seldom correspond with the openings in muscular tissue, owing to the ever-constant change in the position of parts due to movement and muscular action; hence it is frequently difficult to follow the course of a missile with accuracy; when for the purpose of accurate diagnosis it becomes necessary to do so, the relation of the individual to the impinging missile becomes of great importance.

Contusions of muscular tissue are often found as the result of impact of "spent" balls, or when the force of the missile has been lessened by contact with some obstacle, as parts of equipment, books, money, buttons, etc.

The contusions may present all degrees of severity from simple ecchymosis to loss of vitality of the part struck; this may be limited to the skin, in which case an eschar of rounded form and of about the size of the missile is thrown off; or it may affect deeper structures, as the contents of the great cavities.

A soldier found an iron breastplate, which he wore into action; he was struck by a Minié bullet upon the breastplate, over the region of the third rib, and was seriously contused, expectorating a considerable quantity of blood; a rounded excavation of about the size of a musket-ball sloughed at the point where he was hit, laying bare the rib; he recovered, but a companion who wore the same breastplate in a subsequent action was not so fortunate; a conoidal ball struck the plate near its lower border and passed through it, carrying before it fragments of the plate, which entered the abdomen, causing death.

Contusions seem to more frequently follow the impact of round than conoidal missiles.

Wounds by conoidal bullets, by fragments of shell, or by foreign bodies, are more destructive in their nature than those resulting from lesser missiles; the irregularity of a bullet track, due to the causes mentioned, constitutes one great source of danger in flesh wounds; the cavities and irregular pouches found along the track give lodgement to foreign matter driven in with the missile, as shreds of clothing, etc., causing irritation, inflammation, and abscesses, with the retention and burrowing of purulent accumulations, and exposing the patient to the danger of septicæmia, or at least prolonging convalescence.

Many cases attended with extensive destruction of skin, connective tissue, tendons, and ligaments, result in serious disability from contraction and rigidity of parts, and from the formation of extensive cicatrices, impeding motion and becoming the seat of pain and hyperæsthesia.

After shot wounds of the soft parts of the lower extremities particularly, and when there has been great laceration or complications by lodgement of foreign bodies, cases are not infrequently noted in which missiles, without immediately injuring osseous articular surfaces, so injure the surrounding ligaments and soft parts, in some instances even the synovial membrane, as to light up immediate or consecutive inflammation in the capsular cavity, or to induce, through the formation of cicatricial bridles or by other deformities, a diminution or even abolition of the movements of the joint. These injuries are known as periarticular wounds.

Gangrene, tetanus, and pyæmia are not infrequent complications of lesions of the muscles, and, when affecting the extremities, life may at times only be preserved by recourse to amputation.

A few instances of repair of shot wounds by first intention were recorded during the late war, but they were very rare and must presuppose a cleanly cut wound, a sound constitution, and a temperate habit of life.

EFFECTS OF MISSILES AND PROJECTILES IN BONY STRUCTURES.—Gunshot injuries of bones may be classified as contusions, simple fractures, partial fractures, penetrations, perforations, and complete fractures, with varying degrees of comminution and destruction of substance.

Nearly every form of missile and projectile used in warfare is liable to cause these various injuries.

The properties inherent to the missile, as velocity, size, form, weight, and the conditions pertaining to the individual at the time, as posture, part wounded, etc., will determine the nature, extent, and severity of the injury.

Slight forms of injury may result from the impact of a solid shot, a fragment of shell, or from a leaden bullet; injuries of the gravest character may equally be inflicted by these agents.

Contusions of bone more commonly result from the impact of missiles under low velocities, as a spent bullet or fragment of shell, or when the force of the missile has been nearly expended in overcoming the resistance of overlying tissues, or when the line of direction has been oblique to the bone, causing a grazing or glancing blow.

Round balls parting rapidly with their force after their initial velocity is diminished, will generally contuse rather than fracture. The same is true of shell fragments, unless their weight is sufficient to cause fracture by crushing.

Contusions of bone may be followed by no very serious results, as instances of this nature have been reported. In many cases the contusion was at first unrecognized until tardy and faulty cicatrization and discharge of bone proved the presence of caries and necrosis.

Unhappily, a very considerable percentage of cases of contusion of bone prove to be far from innocent, and are followed by a train of most serious complications.

Surgeon John A. Lidell, U. S. V., in an excellent article upon shot contusions of bone, enumerates the consequences of this injury as follows: Ecchymoses of the osseous tissue, ecchymoses of the medullary tissue, osteomyelitis of a simple character, necrotic osteitis, and suppurative osteomyelitis, and says: "Any injury of bone of the nature of a bruise, however trivial it may appear at the time of infliction, may be followed by serious consequences, which it is the duty of the surgeon to anticipate and ward off if possible."

After a bone contusion without fracture, the periosteum is injured and destroyed, if the injury is a serious one, or if proper treatment is neglected and necrosis of the bone sets in.

In crowded hospitals and under unfavorable conditions, such injuries, especially in the long bones, cause suppuration of the medullary canal, which extending itself, finally results in septicæmia through the admission of pus into the neighboring veins.

The experience of the late war seems to favor the opinion that, owing to their better blood-supply and consequent greater vitality, shot contusions of the upper portions of the body give more favorable results than similar lesions of the lower extremities.

The tabulated results from official records are given below:

Numerical Statement of Shot Contusions of the Bones of the Head, Trunk, and Extremities.

Seat of Injury.	Cases.				Percentage of fatality.	Treated by conservation.			Treated by excision.		Treated by amputation.	
	Total.	Recovery.	Fatal.	Unknown.		Recovery.	Fatal.	Unknown.	Recovery.	Fatal.	Recovery.	Fatal.
Shot contusions of the bones of the skull	328	273	55	..	16.7	261	51	.	12	4	..	..
Shot contusions of the pelvic bones.....	30	25	3	2	10.7	25	3	2	..	..	..	..
Shot contusions of the humerus........	22	18	4	..	18.1	18	4	..	..	..	..	..
Shot contusions of the forearm.........	10	8	2	..	20.0	7	1	..	1	..	..	1
Shot contusions of the femur and knee.	205	144	61	..	29.7	140	46	..	..	..	4	15
Shot contusions of the leg and ankle...	194	165	29	..	17.5	157	15	..	..	..	8	14
Shot contusions of the foot............	27	26	1	..	3.7	26	1	..	..	..	..	.
Aggregates..........................	816	659	155	2	19.0	634	121	2	13	4	12	30

Structure has undoubtedly a great influence in determining the severity of the effects of contusion.

Such lesions in the spongy bones or cancellated portions of long bones, attended with extravasation of blood, are very likely to result in extensive and dangerous necrosis, inasmuch as the blood confined within an unyielding structure interferes by compression with the nutrient blood-vessels, or, acting as a foreign body, destroys the vitality of the bone by setting up inflammatory action.

The following case of simple osteomyelitis affords a typical and instructive illustration of one of the frequent and grave results of bone contusions observed during the late war. A soldier aged thirty years was wounded at Cold Harbor, June 6, 1864; he was admitted to hospital for a gunshot wound of the left thigh, in the upper third, inflicted by a conoidal ball which penetrated the front of the limb at the inner side of the femoral vessels, and passing backward and outward through the limb, lodged beneath the skin. It was extracted by an incision behind, and the wound was regarded as one of the soft parts only. His general condition was fair, or rather below par, at the time; for several days the wound did well; about July 1st, it was observed that the patient was failing in strength and emaciating; stimulants, tonics, and a supporting treatment were ordered, but he sank into a typhoid condition, with warm skin but without sweating; the pulse was frequent and feeble, the tongue red and dry, and there was almost entire loss of appetite. He became somnolent and was roused only with difficulty. The discharge from the wound was at no time large, but the leg remained swelled and inflamed. He died July 18th; at the autopsy it was found that the bullet had struck the shaft of the femur on its postero-inner side, two or three inches below the trochanter, *grazing and bruising it.* The aperture of exit had healed; there was an abscess about the place of injury of the bone as large as an orange, and pus had burrowed among the muscles of the thigh; there was a large deposit of new bone about the contused portion of the femur. On making a longitudinal section of the bone, new osseous tissue was found deposited in the medullary canal; the marrow presented the "red inflammatory" appearance described by Virchow; there was no thrombosis nor any lesion of the arteries and veins. The body was much emaciated. No lesions of the intestines or internal organs were found.

Many other cases were not as simple in their course, but were complicated with erysipelas, phlebitis, and pyæmia.

Not a few cases were reported in which no permanent injury was sustained.

One soldier was struck by a conoidal bullet which entered the region of the groin and flattened itself upon the pubic bone. He lay upon the field all night in an unconscious condition, but after having been placed in hospital he did well, and was detailed to duty as a clerk.

Another soldier was struck by a large leaden bullet on the spine of the right tibia, between the middle and lower third; the ball was split to within a few lines of its base, overlapping the bone. A portion of the bone subsequently came away, leaving a depression, but no serious consequences followed.

Instances are also adduced in which missiles were split upon the bones of the forearm, and on the zygoma, but in each case little permanent injury seems to have resulted. In many cases balls were found wedged between bones without doing serious harm.

Simple fractures following shot injuries are infrequent, and generally result from the impact of projectiles of the larger class, as solid shot, grape-shot, or shell fragments, the momentum of which is nearly expended.

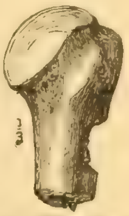

FIG. 4632.—Head and One and a-half inch of Left Humerus, showing Partial Fracture.

An examination of many cases of shot injuries of the bones of the extremities has confirmed the opinion that shot fractures of long bones, without injury of soft parts, are more infrequent than visceral ruptures without external wounds.

Hamilton, in his "Military Surgery," observes: "When the bones of a limb are broken by a solid shot and the integuments are not torn, the fracture is seldom simple, but almost always the comminution is excessive." The cases of simple fractures reported during the war bear out this opinion.

Partial Fractures.—Instances of partial fractures of bone in which a portion of the substance has been cut out without a complete solution of continuity, are occasionally met with. This lesion is more commonly seen in spongy bones, or in the parts of long bones well supplied with cancellated structures. Figs. 4632, 4633, and 4634, from the "Medical and Surgical History of the War of the Rebellion," represent fractures of this kind, and are generally serious from the excessive suppuration and consequent exhaustion. Amputation or excision has commonly to be resorted to for the purpose of saving life. Small missiles, as bullets and small shell fragments, often penetrate a bone and remain fixed with little splintering and fissuring. Instances

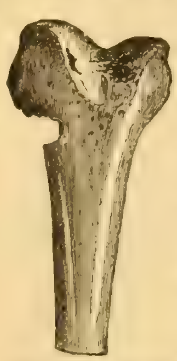

FIG. 4633.—Lower Third of Right Femur, showing Partial Fracture.

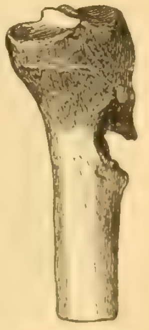

FIG. 4634.—Upper Portion of Left Tibia, showing Partial Fracture.

[illegible] of this nature are [illegible] in spongy bones or in the cancellated structure of long bones. A unique illustration of such an injury is shown in Fig. 4635. An excavation at the base of the great tuberosity of the humerus, the shape and a little greater than the size of a conoidal ball, one inch deep, extends into the head of the bone; the walls of the cavity are perfectly smooth, as if made by design, and there is no fissuring or comminution connected with the injury.

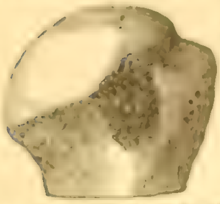

Fig. 4635.—Head of [illegible] Humerus [illegible]

Figs. 4636 and 4637 show the result of penetration of a missile lodged in the cancellated structure of the femur without splintering.

More frequently penetration is accompanied by fissuring and splintering, as represented in Fig. 4638, where a conoidal ball is shown to be imbedded in the lower third of the femur, just above the patella. A fissure extends upward three and a half inches, and another and independent one traverses the outer surface. This patient was wounded by a Minié ball, which perforated the quadriceps femoris close above the left patella, and lodged one inch above the articular surface of the knee joint; recovery followed amputation.

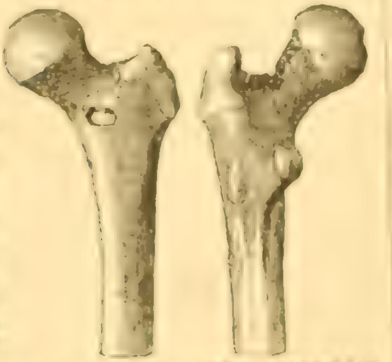

Fig. 4636.—[illegible] Femur. [illegible] by a Missile.

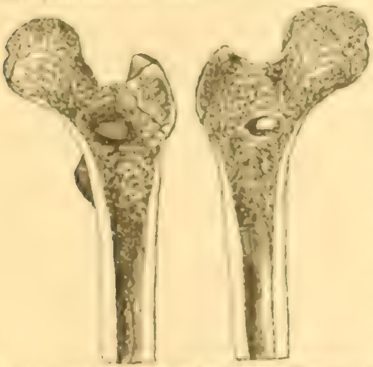

Fig. 4637.—View of Fig. 4636 [illegible] Specimen.

Fig. 4639 shows the upper third of a right femur with a conoidal ball imbedded, point downward, in the anterior aspect, just above the articulation; a fissure extends upward the length of the specimen. The limb was amputated at the lower third of the thigh, the patient dying in a few hours from exhaustion from loss of blood.

Figs. 4640 and 4641 represent specimens received at the Army Medical Museum without histories; they were taken from the battle-fields of the Wilderness and from the front of Petersburg. The fissures do not extend into the knee joint, although the point of impact was close to the articulation.

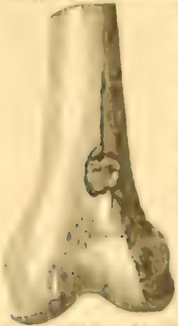

Fig. 4640.—Lower Third of Left Femur. [illegible] by a Musket.

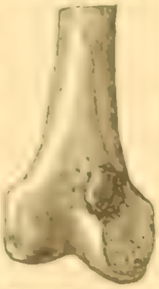

Fig. 4641.—Femur [illegible] Lower Third [illegible] of a Musket.

Perforations of Bone.—When shafts of long bones are perforated there is commonly much splintering, as is illustrated by Fig. 4642. A Colt's revolver ball passed through the upper third of the femur from behind forward, comminuting the bone; death occurred three hours after amputation. In Fig. 4643 the tibia had been perforated below the head, causing longitudinal fissures. Figs. 4644 and 4645 represent a perforation of the lower third of the femur by a musket ball; two longitudinal fissures extend upward, and a slight one enters the joint.

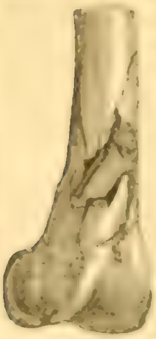

Fig. 4642.—[illegible] by a Missile.

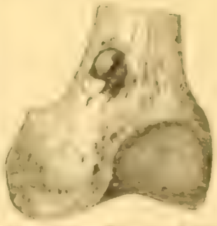

Fig. [illegible].—Fissure of the Lower Extremity of Left Femur by a Musket.

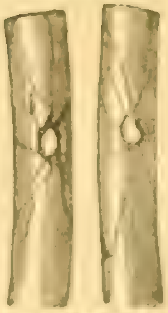

Fig. [illegible].—Section of Left Femur Perforated.

In Figs. 4646 and 4647 the shaft of the femur is perforated, with a longitudinal fissure on the anterior surface extending into the joint and for four inches upward, ending in a slight transverse fissure; on the posterior surface an oblique fracture runs upward for nearly four inches. The condyles are also separated by a fissure. The fracture was made by a round musket ball.

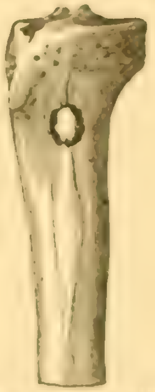

Fig. [illegible].—Upper Third of Left Tibia Perforated.

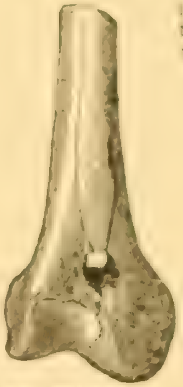

Fig. 4646.—Lower Third of Left Femur Perforated.

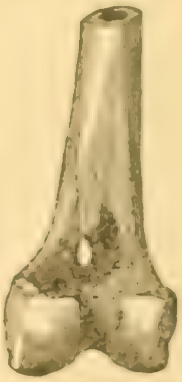

Fig. 4647.—Posterior View of the Specimen shown in Fig. 4646.

Complete Fractures.—In by far the greater number of shot fractures of bones the solution of continuity is complete, the degree of comminution depending upon the attending circumstances.

In rare instances fractures, transverse or oblique, but simple or rarely comminuted, occur. They are commonly due to the impact of nearly spent missiles or to grazing or glancing balls.

Fig. 4648 shows an oblique fracture of the upper third of the left femur, with a minute fissure extending to the lesser trochanter, and a small portion chipped from the anterior face of the

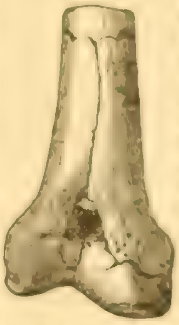

Fig. 4648.—[illegible]

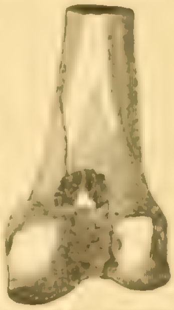

Fig. 4649.—[illegible]

point of impact. Another illustration of this rare fracture is given in Fig. 4649, showing the lower half of the right humerus, apparently amputated because of a nearly transverse fracture through both condyles. In these cases the missile is generally found in close apposition to the fracture.

A form of injury has been noted in which the bones are fractured and comminuted, though less than usual, at the point where the ball impinged, while at a short distance above or below this point an oblique or transverse fracture is produced. When the point of impact is above the middle of the bone, the fracture is below; when below the middle, the fracture is above; Fig. 4650 shows a nearly transverse fracture in the middle of the left tibia, communicating with the point of impact by a longitudinal fissure. Fig. 4651 exhibits the lower portion of the left femur amputated in the middle third, for a perforation with oblique fracture above the seat of injury.

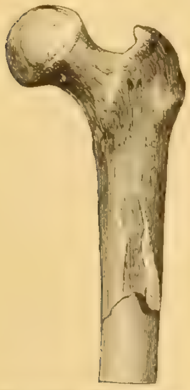

Fig. 4648.—Transverse Fracture of Upper Third of Femur by Conoidal Ball.[1]

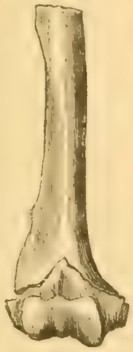

Fig. 4649.—Transverse Fracture in Lower Third of Humerus.[1]

Fig. 4652 represents an extensive longitudinal fracture, implicating the joint, and complicated with an oblique fracture of the lower third.

Fractures of this nature are usually found in the long bones of the extremities, and are probably the result of the direct impact of a missile at high velocity, upon bones somewhat firmly fixed by the weight of the body.

Commonly a bone is broken into many fragments, some of which are entirely detached and driven into the surrounding tissues, while others remain connected with one or another of the fragments by shreds of periosteum.

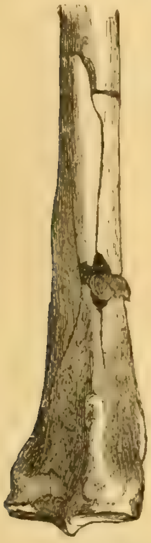

Fig. 4650.—Tibia, Representing Transverse Fracture.[1]

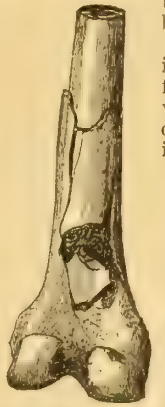

Fig. 4651.—Lower Half of Femur, Showing Transverse Fracture.[1]

Over and above this shattering and comminution, effects common to all forms and varieties of missiles, the extensive splintering and destruction so often found is unquestionably due to the wedge-like form and great force of the conoidal bullet.

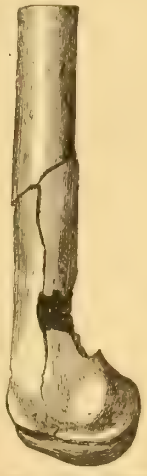

Fig. 4652.—Lower Half of Femur with Transverse Fracture.[1]

When the shaft of a long bone is fractured about equidistant from the epiphyses, the fissures extend upward and downward in about equal proportion; but as the point of fracture approaches the ends, the tendency is to split in the direction of the longer fragment. This is particularly noticeable in fracture of the humerus near the head, when the general tendency of fissuring is downward.

Fig. 4653 represents the excised portion of a left humerus, including the head and four inches of the shaft. The fracture is at the surgical neck and extends with comminution obliquely down the shaft. Fig. 4654 shows the upper half of a right femur; the missile struck the anterior face of the bone a little below the trochanter minor, and shattered and fissured the femur downward. In Fig. 4655 the comminution is represented as extending upward and downward in about equal proportion. The weapon causing this wound was discharged at very close range; a soldier, becoming enraged from some cause, threw his musket from him, causing its discharge; the missile, a Minié ball, entered the right thigh, greatly lacerating the soft parts and comminuting the bone as shown by the figure. The specimen is a fair illustration of the effects of a conoidal ball at short range.

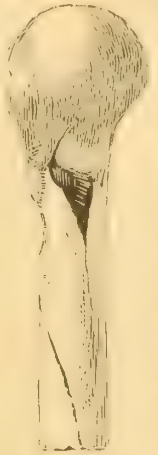

Fig. 4653.—Humerus, Showing Downward Tendency of Fissure.[1]

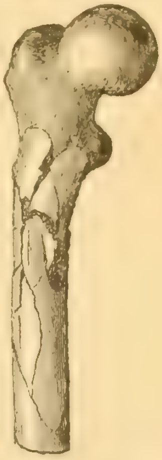

Fig. 4654.—Femur, Showing Extensive Comminution.[1]

From a careful examination of a large number of specimens of long bones in the collection of the Army Medical Museum, it would seem that the statement made by Esmarch is correct, that "in comminution of a long bone the fissures almost never extend into the epiphyses; in the same manner, injuries of the epiphyses, only in some rare cases, extend into the shaft, unless the bullet strikes the adjoining border of both parts, in which case both head and shaft are more or less comminuted."

This is probably due, as Esmarch says, "to the soldier being generally young, and the parts not consolidated." The Army Medical Museum possesses several specimens showing this kind of injury, some of which have been illustrated above (see Figs. 4650 and 4651).

The few exceptions to this rule seem to be in cases in which consolidation is complete, or in which the direction of the missile was such as necessarily to cause this effect, as in Fig. 4656, where fissures extend through the head and into the shaft.

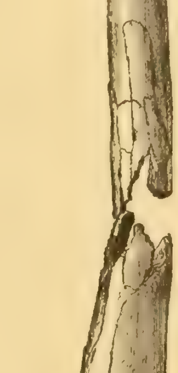

Fig. 4655.—Femur, Showing Extensive Shattering by Conoidal Ball.[1]

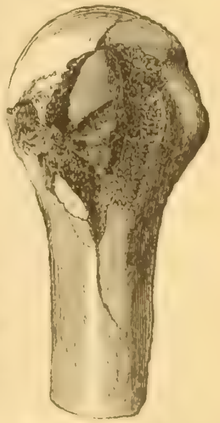

Fig. 4656.—Humerus, Showing Fracture at the Epiphysis.[1]

It has been shown that cases of penetration and perforation of bones may occur without complete fracture; but this is contrary to the more general rule, and even in spongy bones, where we would naturally look for such lesions. It will usually be found that complete destruction of the bone results.

EFFECTS OF MISSILES AND PROJECTILES ON NERVES.—Shot wounds and injuries of nerves afforded a wide field for observation and study during the late war.

Wounds of this class, not implicating the great nerve centres, and not complicated by severe lesions of other tissues and parts, show a very small percentage of mortality, but comprise a class of injuries which result too often in great and permanent disability, attended with intense suffering and misery, and are often but little amenable to treatment.

Early in the late war a hospital for the reception and treatment of this class of injuries was established by the Government in Philadelphia, Pa. Acting Assistant Surgeons S. Weir Mitchell, George R. Morehouse, and W. W. Keen, Jr., United States Army, were placed in charge, and to the experience of these gentlemen in the study and treatment of the large number of cases in their care we are indebted for the most valuable contribution to the literature of a much neglected subject.

With reference to the above hospital, the surgeons in charge remark as follows: "Among the cases were representatives of every conceivable form of nerve injury—from shot and shell, from sabre cuts, contusions, and dislocations. So complete was the field of study that it was not uncommon to find at one time in the wards four or five cases of gunshot injury of any large nerve. It thus happened that phenomena, which one day seemed rare and curious, were seen again in other cases the next day, and grew commonplace as our patients became numerous."

The immediate effects of shot injuries of nerves were pain—not generally felt locally, but at some point in the distribution of the nerve; when a nerve was completely divided, total loss of sensation in the parts supplied by it; shock more or less profound, proportionate to the reflex disturbance; and paralysis of motion and sensation, complete or partial.

Of forty-eight cases of severe shot injuries of nerves, selected with a reference to the study of the immediate effects of injuries, Drs. Mitchell, Morehouse, and Keen found that "by far the greater number felt, when shot, as though some one had struck them sharply with a stick," and that "about one-third experienced no pain nor local shock when the ball entered. More rarely, the pain of the wound was dagger-like and intense, while a few, one in ten, were convinced for a moment that the injured limb had been shot away; in two instances of neck wounds the pain at the moment of wounding was intense, and was referred to the insertion of the deltoid muscle."

In a case of shot wound of the leg, it is reported that the patient felt no pain, but had so vivid an "impression" of a wound in the other leg, that he found it difficult to get rid of the erroneous idea.

With reference to the shock from wounds of nerves, the same authorities say: "Every case of wound of nerve trunks in the legs fell instantly, and not one of the twelve so wounded lost consciousness; yet, in gravity and in the size of nerves injured, these were among our worst cases. Of the remaining thirty-one, seven fell instantly, unconscious; one only of these bled very largely. Of the seven, all were wounded in the neck, face, or arms.

"Of the total number of arm cases, eighteen in all, two were of the class described above as falling senseless; of the remainder, two only fell, but with entire consciousness and in full possession of their senses. Fourteen continued standing or walked away. Of the wounds of the lower neck and axilla, brachial plexus or axillary nerves, one fell senseless, four fell conscious, and the remaining eight suffered no immediate fall. If, then, we regard the fall with loss of consciousness as the most marked expression of the condition known as shock, we shall have some right to infer that it is most likely to be felt severely in wounds about the upper third of the body."

In paralysis of nerves, motion is more frequently impaired than sensation. While it would naturally be supposed that both motor and sensory fibres would suffer equal damage by a missile striking or contusing a nerve, it is found that practically the motor fibres suffer most seriously; and this is true of all stages of such cases. Lesions of motion are always the least readily relieved, and the last to improve.

Of the forty-eight cases above alluded to as having been studied by the authorities named, five were reported as being wounds affecting nerves of single function; of the remaining forty-three, thirty-two exhibited total loss of motion with defective sensation, or entire loss of that function. In the remaining eleven there was partial loss of motion, and usually slight loss of sensation. In defining total loss of motion it must be understood that the whole limb became powerless at once.

Of injuries caused by shot wounds of the great nerve centres, it may be stated in general terms that the greater percentage of such injuries proved fatal at once, or within a very short period. Those that survived the original injury most generally became the victims of insanity, epilepsy, or chorea.

When the spinal cord is severed or seriously involved, a fatal issue ensues more or less remotely.

Aside from these graver injuries are found innumerable cases of shot lesions in which it is evident that damage is done to the nervous centres by concussion, compression, or contusion, or in which are presented the phenomena of reflex paralysis.

The following cases, taken from the records of the war, will serve to illustrate these lesions and injuries of the spine:

In the case of a soldier wounded at Gettysburg, July 1, 1863, a Minié ball entered the back at the angle of the right shoulder blade, passed across, and was extracted three inches below the left shoulder blade, escaping the [illegible]. The patient complained of numbness and loss of power in the legs; no displacement or tenderness of the spinal column was apparent. He was discharged the service in January, 1864, on account of partial paralysis of the lower extremities, the result of his wound, and was pensioned.

The last report received by the Pension Office in his case, September, 1877, states that the pensioner has only partial control of his bladder and rectum. This is not an uncommon result of what are at first considered trivial wounds.

Lieutenant J. F. M. was wounded June 27, 1863, by a Minié ball, which struck him two inches to the left of the spinal column, opposite the first lumbar vertebra, and followed up the spinal column until it reached the spinous process of the first cervical vertebra, where it turned to the left, and was cut out from beneath the skin over the middle third of the sterno-cleido-mastoideus muscle. The lower half of his body was paralyzed; his symptoms continued to grow worse and he died July 12, 1863.

A color-sergeant was wounded at Vicksburg, May 19, 1863, and was discharged the service for shot wound of the spine, with fracture of the spinous and transverse processes of the ninth, tenth, and eleventh dorsal vertebræ; the ball struck the crest of the left ilium three inches back of the anterior spinous process, passed through near the sacrum and lumbar vertebral articulation, and was cut out two inches to the right. A year later he is reported as a complete paraplegic; the wound of entrance is discharging, and an opening over the spine gives vent to pus and pieces of the vertebræ. In 1874 the pensioner is reported as wearing an apparatus to support the upper part of the body, without which he has no power to sit erect; the legs are entirely useless, and he requires the services of a personal attendant continually.

In some cases it happens that the spine itself escapes direct injury, but the lodgment of a missile in close proximity to the nerve centres causes compression of the adjacent branches.

The following case illustrates what is known as concussion or "commotion" of the spine; it is not supposed that any large nerve could have been touched : The patient, a soldier, was accidentally shot, while sitting upon a fence rail, by a pistol-ball ; it entered at the median line, exactly over the interspace between the spinous processes of the sixth and seventh cervical vertebræ, and was cut out on the left side of the neck one inch below the angle of the jaw. No bone escaped at the time, and the surgeon who examined him felt assured that there was no fracture. The patient thinks he was looking to the left when shot ; if he be correct as to his position, the ball could have come near to no part of importance except the spine, and in any case, it would be difficult to assert that it could have wounded the cervical, and still less the brachial, plexus. He fell senseless, and was conveyed to a hospital tent, but recovered his senses within two hours. He then found that he had neither motion nor feeling in any of his limbs—the trunk was equally powerless, and he was unable to feel the bed upon which he rested. Gradually, sensation first, and then the power of voluntary motion, returned to the whole right side. Within a month the left side improved, with the exception of the left arm. Five months after the injury his condition is reported as follows : General loss of flesh, left arm markedly atrophied ; no notable difference in legs ; the left shoulder much atrophied, especially the deltoid ; the left hand is congested and swollen, with burning pains in the palm ; the left leg is weaker than the right, and his gait is awkward from his swinging his right leg outward and forward.

Cases of reflex paralysis are met with as a result of shot wounds of nerves, and among those recorded may be mentioned those in which paralysis of some remote part or organ has been occasioned by the injury done to some large nerve, or to some portion of the body which is richly supplied with nerve branches of even secondary size and importance.

These injuries are rare ; of sixty or more studied by Mitchell, Morehouse, and Keen, only seven cases of reflex paralysis of remote parts or organs were met with in which the influence was severe or prolonged. In the majority of the cases reflex effects are slight and transient, and could perhaps be better observed on the battlefield, was not the attention of surgeons taxed to the utmost by the more palpable wounds thrust upon them.

Among the reflex effects alluded to may be classed the cases of syncope, arrest or disturbance of the heart's action, the great pallor, weakness, and depression attendant upon shock after injury ; and among the more severe and prolonged effects, paralysis of sensation and motion, and of special senses.

But few cases of injuries of nerves of special sense caused by missiles are recorded as having occurred during the late war. Among these are noted two cases involving the whole or branches of the sympathetic nerve ; two cases of shot wounds of the portio dura of the seventh pair, and one of injury of the facial nerve resulting in facial paralysis and great distortion ; this latter patient also suffered loss of sight in the left eye, and of hearing in the left ear.

Nerve-trunks may be completely severed by a missile, or they may be partially divided and lacerated ; they may be contused by the near passage of a missile which has insufficient power to divide or lacerate, or which has expended its force on neighboring tissues. As in the case of arteries, their position and surroundings tend to protect them, and it is probable that their mobility and form may enable them to slip aside and escape damage from a passing missile.

Mitchell, Morehouse, and Keen add to the above more common forms of shot injury, those from cicatricial pressure, and those from the extension of diseased processes from wounded nerves to those which are healthy. The same authors consider injuries from concussion of a nerve to be those "most apt to be permanent and serious." The persistence and severity of the symptoms—such as shock, pain, and partial or complete loss of motion and sensation—and the extent of loss of function, seem to indicate, in some degree, the remote effects generally to be expected.

Instances of immediate death from injuries of nerve-trunks are probably rare, though it is not difficult to conceive of such disturbance of central ganglia as may induce a fatal result, and actual cases of this kind are not wanting in the records.

The important labors of Mitchell, Morehouse, and Keen in the vast field presented by the organization of a hospital for diseases and injuries of nerves, cannot be better appreciated than in their clinical observations upon the remote effects of nerve injuries.

"Most of the cases presented phenomena which are rarely seen, and which were naturally foreign to the observation even of those surgeons whose experience was the most extensive and complete. Nowhere were these cases described at length in text-books, and their treatment was passed over in silence. In the great monographs on military surgery this defect is still so complete that wounds of nerves are there related rather as curiosities and as matters for despair, than with any view to their full clinical study and systematic treatment."

In cases of nerve injury, immediate symptoms, when not severe, may pass away, leaving the patient uninjured, but by far the more common result is that, while there may be a temporary improvement, there is a permanency of certain symptoms, especially those of paralysis of movement and sensation. As time progresses, others are added which give the case a hopeless aspect, viz., altered nutrition, changes in calorification, persistent pain, and other sensory phenomena.

Atrophy of muscles certainly follows complete division of nerves, when there is no subsequent repair. The muscles waste, the areolar tissue shrinks, vessels fade from view, and the pulse becomes feeble and small. These processes go on with certainty until nothing is left but bone and degenerated areolar tissue, covered with skin altered in its appearance and functions.

Among the forms of altered nutrition, that of the skin, noticed by Paget, is not infrequently seen ; reference is made to the "glossy fingers ;" in well-marked cases the fingers which are affected—and it may be confined to one or two of them—are usually tapering, smooth, hairless, devoid of wrinkles, glossy pink or ruddy, or blotched as if with permanent chilblains ; they are commonly very painful, especially on motion, the pain extending up the arm. In most of the cases this condition of the fingers is attended with very distinct neuralgia, both in them and in the arm. Out of fifty partial nerve lesions under treatment in the hospital for nervous diseases and injuries, this condition existed in nineteen, and the description of the symptoms agrees well with that of Paget.

Eczematous eruptions are a frequent accompaniment of this condition of the skin.

In many cases of altered nutrition, the hair disappears from the affected region, and a remarkable alteration in the nails is noticed, consisting in longitudinal curving, and an extreme arching, with, generally, a thickening of the cutis beneath its extremity ; distressing ulceration is apt to occur at the angles of the nails of the toes, when they are affected, which is inveterate, despite every care and attention.

Acute, painful swelling of joints is often a sequence of nerve injuries ; it is distinct from swelling due to inflammatory action about the wound, but is more permanent and persistent ; when the acute stage passes, the tissues about the articulations become hardened, and partial anchylosis results; so that, in many cases, the only final cause of loss of motion is due to this state of the joints. Of all agencies which impede movement, it is the most difficult to relieve.

After complete division of nerves the secretions of the skin are generally absent, while incomplete division results in a variable condition of this function ; in some cases there is excessive sweating, limited to the area of the surface affected. Cases of perverted secretion, acid sweating, and perspiration of a disgusting odor have been noted after incomplete division of nerves.

Lesions of sensation are always present in some degree. Hyperæsthesia and anæsthesia are very comrently observed. Neuralgia is of great frequency and persistence, stubbornly resisting treatment. Its favorite seats seem to be the hand and foot; other portions of the body are less frequently attacked. Severe neuralgia may, in some instances, be due to the presence of foreign bodies, as fragments of lead from a bullet, splinters of wood, bone, or bone pressing upon or imbedded in a nerve-trunk. The pain in such cases is always acute and persistent. Not infrequently neuralgia assumes such an intensity as to react upon the whole economy, leading to nervous prostration and break-down.

Paralysis of the motor nerves from shot injuries varies in all degrees of intensity and completeness. The following case presents interest on account of the motor lesion, and also as presenting well marked reflex effects:

A sergeant, engaged in scouting, was wounded by three bullets (slugs), one striking the right hip, another the right arm, and the third lodging in the left shoulder. The wounds of the hip and arm gave no subsequent trouble; the wound in the shoulder was deep and painful.

The slug entered just over the third left rib, about in a line with the middle of the clavicle, and passed upward and backward, lodging in the deep muscles. The pain was sharp and tingling, accompanied by a buzzing or throbbing sound in the left ear, and the eyes became very sensitive to light; all these symptoms gradually disappeared, and he rejoined his command. In about a year his eyesight had failed to such a degree as to require positive glasses, and he suffered attacks of neuralgia of the cardiac region.

This situation remained unchanged for nearly twenty years, when he fell down a flight of stairs, striking upon the left shoulder. The day after the fall, while writing, he suddenly lost the power over the fingers of the left hand, and soon after the whole left arm became powerless. He could not rise from his chair on account of weakness of the left leg, and soon paralysis of the whole left side ensued. His general condition improved in a few days, leaving the left arm and hand useless.

Feeling that the slug in the shoulder was probably the cause of the trouble, he had it removed; it was about the calibre of a lead pencil, three-fourths of an inch long, and flattened at both ends; it weighed one hundred and twenty-seven grains. After the removal of the slug the numbness gradually disappeared from the hand and arm, and in six weeks these members had recovered, with the exception of a slight weakness. The eyesight, which for nearly twenty years had compelled the use of glasses, improved to the extent that they were no longer needed or used. There was also great diminution of the cardiac neuralgia from which he had long suffered.

The prognosis of motor injuries is uncertain, and is largely dependent on whether the loss of function is complete or incomplete; if a muscle responds to the will after the injury, there is a reasonable hope of increasing gain and restoration of power; early loss of tone, rapid shrinking of muscular tissue, and contraction, when not merely spastic, are bad indications. They show loss of nutritive fibre, and result in deformity and permanent loss of power.

As results of motor paralysis are found loss of motion from [illegible] joints, contracted muscles, spasmodic affections, and tremors.

Drs. Mitchell, Morehouse, and Keen made a series of carefully conducted experiments on the condition of calorification in injuries of the nerves. The results of a number of grave cases are summed up as follows: "It was observed that the member the nerves of which were affected, was nearly always colder than the other, whether the nerve lesion was extensive or trifling. In two cases there was no difference. One of these was an instance of total motor palsy below the knee, with good tactile feeling preserved, and without [illegible]. The other was a wound of the portio dura of the seventh nerve; the motor palsy complete, sensation perfect. Five cases had a higher temperature in the wounded limb than in the normal member. At the time of the observations we had no wound in which complete division of all of the nerves of a part had occurred; and in fact this is a rare accident. The sole exceptions were wounds of the seventh pair. One of these we examined as to temperature, but with no notable result: there was no difference between the two sides."

EFFECTS OF MISSILES AND PROJECTILES ON BLOOD-VESSELS.—Wounds of blood-vessels by missiles and projectiles were few in comparison with the total number of shot wounds received during the late war. In the general consideration of these injuries, the question as to the particular character of the missile does not appear to possess much practical importance. In fact, it is difficult to distinguish the effects of injuries inflicted by one or the other of the more common forms of bullets.

It is probable, from the general conditions pertaining to missiles, that a round ball will more frequently contuse than divide a blood-vessel, while the contrary may be expected to result from an injury by a conoidal bullet; but perforations by round balls have been observed.

Distorted balls, pieces of shell, fragments of stone and iron, and splinters follow the general rule common to all missiles, by contusion, cutting, and punctuating blood-vessels.

The graver lesions due to the impact of large projectiles are so manifest in their character as to need no comment.

The position of the larger trunks of the principal blood-vessels tends to give them immunity from accident.

They are deeply placed, sheltered by bony framework, protected by soft parts and by fasciæ capable of deflecting the course of a missile; their investing sheaths are strong and tough, having a certain degree of freedom of motion; they are able to slip aside and elude a passing missile; their tubular form and easily compressed fluid contents are also elements of safety.

All of these conditions may have their influence in contributing to the many fortunate escapes from severe, perhaps fatal, injury common to the experience of every military surgeon.

The following are cases in point:

A soldier was wounded while on picket by a ball, whether round or conoidal is not known, which entered the right thigh near the lower angle of Scarpa's space, crowded or pushed aside the femoral vessels, passed upward, and escaped posteriorly. Very little hemorrhage followed, though he walked a considerable distance. No bad symptoms developed, and he made a rapid recovery.

In another case, a musket ball lodged between the carotid artery and jugular vein, pressing the vein forward to such an extent that the vessel was collapsed and little or no blood passed through it.

In still another case, a musket ball passed on a level with the pomum Adami between the jugular vein and carotid artery, without injuring either vessel.

Aside from the injury of large trunks which are immediately fatal, it would appear that the number of cases of wounds of important blood-vessels is small. It is stated that in the campaign of the Army of the Potomac from the Rapidan to the James in May, June, and July, 1864, of a total of [illegible] gunshot wounds, only [illegible] belonged to this category.

Dr. Longmore ("Gunshot Injuries," [illegible]) says: "Out of [illegible] wounds detailed in the British returns of the Crimean War, only 17 wounds of arteries were registered."

Surgeon Goldsmith, U. S. V., desiring to know whether external primary hemorrhage often occurs as the instant result of shot wounds, placed himself near the line of battle and observed only one case, a soldier struck in the neck, the ball severing the carotid, and resulting fatally before he could reach him.

In the following case almost instant death ensued from the perforation of the carotid artery. Lieutenant-Colonel F. A. K. was shot at Suffolk, Va., at about 4 A.M., April 12, 1863. He uttered a brief ejaculation after he was shot and died instantly. At the autopsy made upon the body it was found that the common carotid was absolutely perforated from before backward, there being a roundish opening in the anterior, and a somewhat longitudinal one in the posterior wall, the two lateral portions being entire; the par vagum and jugular vein were uninjured. The missile was a conical pistol-ball, and quite a size larger than the diameter of the artery.

The passage of a missile through any part of the body will necessarily divide and lacerate many small blood-vessels, but serious hæmorrhages seldom follow, as permanent retraction of the wounded vessels takes place at once.

When an artery of some size is completely divided by the impact of a large or small projectile at high velocity there may be a gush of blood; but the immediate retraction of the inner and middle coats, and the formation of a coagulum, will generally prevent further hæmorrhage, and secure the patient for the time, at least.

In 84 of 118 cases of complete division of the large arteries no primary bleeding was observed, while in 34 cases, or 28.8 per cent., the injury was followed by primary hæmorrhage.

Summary of One Hundred and Eighteen Cases of Complete Division of the Larger Blood-vessels, Indicating the Number of Cases in which Primary Bleeding Occurred.

Arteries.	Cases.	Results.		Primary bleedings.		No primary bleeding.	
		Recoveries.	Fatal.	Recoveries.	Fatal.	Recoveries.	Fatal.
Complete division of common carotid	2	..	2	..	1	..	1
Complete division of internal carotid.	1	..	1	..	..	..	1
Complete division of axillary	6	..	6	..	1	..	5
Complete division of brachial	15	10	5	3	2	7	3
Complete division of radial	10	6	4	3	..	3	4
Complete division of ulnar	6	4	2	1	..	3	2
Complete division of femoral	31	5	26	1	13	4	13
Complete division of popliteal	20	6	14	3	2	3	12
Complete division of tibial	24	6	18	..	3	6	15
Complete division of peroneal	3	1	2	.	1	1	1
Aggregates	118	38	80	11	23	27	57

The proportion of primary bleedings to the number of cases in which the vessels were completely divided is rather larger than that observed by Dr. Lidell, who found that in twenty cases the bleeding ceased spontaneously in all but three.

In some cases, in which the division of the blood-vessel is followed by primary hæmorrhage, it is possible that some foreign body may be thrust into the open lumen of the artery which will prevent retraction, while insufficient to act as a plug; or that there may have been paralysis of the nerves of the arterial coats, preventing their retraction.

Cases of partial division of vessels more frequently come under the observation of the surgeon. In these cases it is usually found that only a portion of the calibre of the vessel is carried away, or that perforation has taken place.

Under such circumstances the retraction of the vessel is rendered impossible, and hæmorrhage ensues proportionally to the size of the artery and of the wound. A case of shot perforation of the carotid has been cited above; and a perforation of the right primitive iliac is shown in Fig. 4657. The injured man died in twelve minutes. If a wounded artery is large the hæmorrhage will be profuse and attended with speedily fatal results, unless help is at once at hand, as in the case of an officer who was wounded by a partially spent rifle-bullet in the front of the left thigh. Profuse hæmorrhage ensued, followed by syncope. Several surgeons were close at hand and promptly arrested the bleeding with a tourniquet; later the wound was enlarged and the femoral artery ligated above and below the injured point. The wound was situated about four inches below Poupart's ligament, and about an inch below the profunda. On the eighteenth day there was a second hæmorrhage of about eight ounces; it ceased with compression and quiet, and there was no return. Had not this officer received instant help, a fatal issue could hardly have been averted.

In the case of a soldier whose femoral artery had been perforated there was copious, instant hæmorrhage, which was arrested by the prompt application of a tourniquet. Bleeding recurred on the sixth day, and was again arrested by pressure; the wound became unhealthy, and the patient died on the tenth day after the injury. Prompt operative interference would have afforded a chance of life.

Sometimes hæmorrhage will continue, though it may be retarded by the formation of a coagulum in the track of the wound; but the tendency is to form a diffuse traumatic aneurism, which, untreated, will exhaust the patient by frequently recurring hæmorrhages.

In the greater number of cases injury to blood-vessels was caused by contusion.

Missiles with low velocities, or those whose force is partially expended previous to contact with the artery, seldom divide or penetrate the vessel, but contuse the arterial coats, destroying or impairing their vitality, and establishing inflammatory action which results in the removal of a slough at definite periods, accompanied by profuse secondary hæmorrhage. In some cases the resulting inflammation, or the injury to the vasa vasorum, effects a partial or complete occlusion of the arterial tube; if the collateral circulation becomes well established, recovery may take place; but fatal gangrene of the extremity, deprived of its blood-supply, very commonly supervenes.

This condition is well illustrated by the case of a soldier who was wounded in the superior portion of the left thigh, and posterior part of the neck of the left femur. After considerable exposure upon the battle-field, the left leg and foot of the patient were found to be cold and insensible; shortly after, a line of demarcation appeared encircling the ankle at the malleoli; amputation at the union of the middle and lower third of the leg was performed, but the man died on the forty-eighth day after the injury. An autopsy showed the course of the ball to have been posterior to the femoral artery, impinging upon its sheath, for the wall of the artery was thickened at this point and was of a brownish color, and the calibre of the vessel was diminished one half; a fine coagulum filled the sheath for a distance of one inch below the track of the ball. The gangrene in this case was clearly due to the diminution of the calibre of the artery, assisted probably by the exposure to cold and wet which the soldier had suffered.

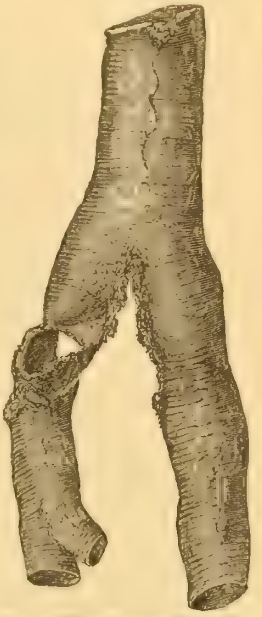

FIG. 4657.—Showing Shot Perforation of Right Primitive Iliac Artery.[1]

Not infrequently, spicula of bone, driven before a missile, puncture vessels, and although they may not be productive of immediate trouble, set up inflammatory action, followed by ulceration and sloughing with secondary hæmorrhage.

A soldier received a compound fracture of the lower third of the femur, by a conoidal ball, necessitating a secondary amputation at the middle third of the thigh. The femur was found to be much shattered, and the popliteal artery ruptured by a spiculum of bone.

Wounds closely resembling incised wounds are caused by sharp-edged shell fragments flying with great velocity; but a certain amount of contusion and laceration, always present, separates them from the class of purely incised wounds.

Missiles and foreign bodies lodging sometimes act as plugs, controlling for a time hemorrhage from a wounded blood-vessel. An interesting case of occlusion of the common carotid is reported by Surgeon John A. Lidell. A soldier died of secondary hemorrhage, who had been wounded by a round ball, nearly spent, which had struck the lower eye-lid, forward, and had been deflected downward, backward, and a little forward in such a manner as to pass obliquely through the left carotid artery and to lodge in the sheath of that vessel underneath the omohyoid muscle, pressing somewhat upon the par vagum, and occluding completely the proximal end of the divided artery. The hemorrhage occurred fourteen days after the injury. It came on suddenly and was very profuse, causing death in a few hours. At the autopsy it was found *that the divided carotid artery was still occluded on the side of the wound toward the heart by the impacted ball; that the hemorrhage occurred from rupture or spontaneous sloughing of a small fresh coagulum which had formed on the distal extremity of the wounded artery; that the hemorrhage was evidently but recurrent in character; and that it would not have been arrested without the application of a ligature to the vessel on the distal side of the wound.* A remarkable and unique feature of this case is that the traumatic aneurism had formed on the distal end of the divided common carotid artery, the occurrence of which seems to have been favored by the free anastomosis which exists between the terminal branches of both the external and internal carotids of the two sides of the body.

In another case an autopsy revealed the presence of a ball resting upon the right vertebral artery, which had been extensively lacerated at the point where it passes through the foramen of the transverse process of the atlas, and had probably acted as a plug in preventing hemorrhage from that artery, as no clots of blood were discovered at the seat of injury. Death in this case was the result of repeated secondary hemorrhages from a traumatic aneurism of the right internal carotid artery, which had been wounded by the missile in its course.

LODGMENT OF MISSILES AND PROJECTILES.—Cases of lodgment of missiles, projectiles, and foreign bodies in the persons of the wounded in battle are common, and many such are noted during the late war.

Round balls are more prone to lodge than those of a conoidal form, as would naturally be inferred from the rapidity with which the former lose their initial velocity, and the resistance offered to their passage through the tissues of the body.

Conoidal balls at ordinary range preserve sufficient force to perforate the body; but at long range or with velocity diminished by contact with intervening objects before reaching the body, or when the position is such as to compel a long course through the tissues, lodgment very commonly occurs. As a general rule, the lodgment of conoidal missiles is deeper than that of round balls.

The collection of the Army Medical Museum at Washington, D. C., furnishes many specimens, not only of missiles and projectiles proper, removed from the persons of soldiers, but also of foreign bodies, as coins, buttons, pieces of pocket-knives, shreds of clothing, portions of the accoutrements of the soldier, and fragments from objects carried by the force of missiles, as iron wire from the bail of a tin bucket, a portion of a ramrod, a tompion nearly entire, etc.

Not infrequently, pieces of bone or teeth from a wounded comrade, driven before a missile, become themselves wounding missiles.

Splinters of wood and iron, stones, and débris from artillery caissons and carriages, from breastworks and defences, act in a similar manner.

All parts of the body share the liability to lodgment.

The direct effects of lodgment are those common to the presence of foreign bodies generally in the tissues of the human structure; they become the centres and sources of irritation, liable to be followed by symptoms of every degree of severity in nature's efforts to rid herself of the offending matter.

The symptoms largely depend upon the size, nature, and form of the intruding body; also upon the region of the body involved. The most serious results follow the lodgment of missiles and foreign bodies in joints and cavities of the body, or in organs necessary to life; even small missiles, with qualities the most irritating, may be the source of great mischief by the production of tetanus and hemorrhage, when lodged where they may cause pressure upon nerves and blood-vessels.

Passing from the more immediate or primary effects of irritation and inflammation resulting from the lodgment of foreign bodies, we find that the usual tendency of their continued presence is to prevent or retard the process of healing. Cicatrization is thus said to be interfered with by such aggravation of the primary irritation; the wound takes on a condition of chronic inflammation, sinuses form with purulent discharges, sapping and undermining the strength and vigor of the patient, and opening the way for the invasion of any of the surgical complications.

Especially does this seem to be true of substances of organic nature, as shreds of wool or cotton, or splinters of wood.

Until such substances are removed, by nature or art, the progress of the case is usually held in abeyance.

Foreign bodies of a metallic nature, particularly those with smooth surfaces, seem to rest more quietly, frequently permitting the closure of the wound; but if their location is such as to subject them to frequent movements, the wound is liable to reopen; this process will be repeated until the offending body is removed or discharged.

Lodged missiles tend to move or change their position. Slowly and gradually the substance will work to the surface of the body, where it will form an abscess and be discharged; or it may tend toward the internal surfaces of the great cavities, where its presence may be productive of harm; or, on the other hand, it may be harmlessly ejected from the body. Thus balls lodged in or about the abdominal region, and of which the exact position had not been ascertained, have finally been passed at stool *per vias naturales*.

Scraps of iron and lead have been known to work their way through the coats of the bladder, where they became the nuclei of vesical calculi, which were subsequently removed by lithotomy. The collection of the Army Medical Museum contains several fine specimens of this nature; also of portions of bullets and shell fragments which had been similarly lodged in the bladder and removed by operation.

The least harmful effects of lodgment are seen in the cases of balls lodged in the muscular or cellular tissues of the body, and in regions of little vital importance.

Musket balls have remained encysted for years, causing little or no inconvenience. It is not uncommon to find old soldiers who have carried encysted bullets in their person for years. The writer has in mind the cases of two soldiers, one wounded in the lower maxillary region during the Mexican war, the other in the gluteal region during the late war, in both of whom the balls are firmly encysted; the missiles give so little trouble that the suggestion of removal is not received with favor.

A most remarkable instance of the encysting of a ball, is that of an officer of the late war, who carried for fifteen years a full-sized conoidal bullet in the cancellated structure of the condyles of the femur, experiencing but little trouble from its presence.

PRIMARY SYMPTOMS COMMON TO GUNSHOT WOUNDS.—The immediate symptoms common to shot injuries are pain, shock, and hemorrhage.

To be duly appreciated they must be seen early, as they are speedily evanescent, fatal, or merge themselves into conditions pertaining to the later stages of shot injuries.

Shock.—Severe shot injuries, particularly those involving the larger bones and the more important cavities, are followed by a train of phenomena known as "shock," or a general perturbation of the reflex nervous system. Upon the reception of such injuries the recipients suddenly turn pallid, tremble, and may fall to the ground;

the surface of the body is cool and bathed in profuse perspiration ; the features often indicate anxiety and distress, the respiration is labored and sighing ; the circulation is feeble ; there may be loss of consciousness to a greater or less degree ; the mind is often agitated as with fear, or there may be an entire loss of self-control ; finally, shock may result in death without reaction.

The degree of shock seems to bear some relation to temperament, to physical condition, and to the region of body affected. Equal degrees of injury affect individuals differently ; while some are apparently overwhelmed, others maintain their self-control and composure ; in some shock seems to heighten the excitement under which the individual is laboring during a battle ; in others the effect is to produce timidity and panic. As a rule, the more severe the injury the greater will be the degree of shock.

Injuries caused by the larger projectiles, as the loss of a limb near the trunk, are generally followed by depressing shock, and this independently of any loss of blood.

Shock is more profound and persistent in grave wounds of the abdomen than in wounds of any other part of the body. Profound and fatal shock has been the occasional consequence of shot contusion of the abdominal parietes.

Wounds producing great splintering and comminution of long bones are generally followed by a severe degree of shock.

The duration of shock is very variable, sometimes lasting but a few minutes, at other times showing great persistence and continuing for hours or days ; here, too, individual temperament and idiosyncrasy seem to exert a great influence. When shock is very persistent the prognosis must be very guarded, as its persistence may depend upon some severe or fatal injury not recognizable at the time ; as was probably the case in the instance of a soldier who was struck by a Minié ball under the left shoulder : the blow caused him to fall across a railroad track, upon his left hip. He complained of this more than of the wound ; suffered intensely from pains in hip, back, and leg ; his urine had to be drawn by catheter ; all the nervous symptoms increased in intensity, and he never recovered from the shock of the fall, and died eleven days after the reception of the injury. Of twenty-seven fatal cases of shock recorded, fourteen were found to be shot wounds of the abdomen, and eight of the femur. Longmore ("Gunshot Injuries," etc.) found that out of twenty-two deaths from shock, only eight were caused by bullets, and in all of these the cavity of the abdomen had been penetrated by the missile. In the remainder the injuries were from gunshot, shell, or grape.

Pain.—Pain, as a primary symptom of shot injury, is rarely absent. In degree it may be slight or severe, according to the locality of the wound, its nature, and the mental condition of the individual. In simple flesh wounds it is commonly described as stinging or cutting, as from a blow by a cane ; it is sometimes likened to the passage of a hot wire thrust through the part ; by others it is described as dull, like a blow from a heavy body.

When nerves are injured or contused the pain is generally severe, and is commonly referred to parts supplied by the nerve.

In severe wounds, generally, the pain which accompanies them is lost in the anæsthesia of the shock which soon follows.

Pain following shot contusions of bone is often severe and widespread, especially if the injury is insufficient to cause unconsciousness,

Under the stimulus of great excitement, as that prevailing during an active engagement, men may receive wounds without being aware of the fact, until their attention is drawn to the blood flowing from the wound, or until they are affected by faintness from the loss of blood.

The white races, as a rule, seem to be more susceptible to pain, and to suffer more acutely.

The negro soldiers engaged in the late civil war bore their sufferings with great fortitude and patience ; but it is questionable if the actual degree of suffering was as great as that of the white soldiers.

The nervous and sanguine temperaments show a greater capacity for suffering than the lymphatic or lethargic temperaments.

Primary Hæmorrhage.—Primary hæmorrhage, or the loss of blood immediately upon the receipt of an injury severing or wounding a blood-vessel, has been alluded to as causing speedily fatal results, or as ceasing spontaneously by the retraction of the coats of the bleeding vessels, or as being so retarded upon the occurrence of syncope as to allow assistance to reach the wounded man, rendering him secure for the time, at least. As a result of the experience of the late war it may be stated that primary hæmorrhage, within the bounds of possible succor, was infrequent ; yet, without doubt, many wounded men perished through lack of self-possession, want of coolness, or of sufficient knowledge to save themselves.

It is probable that a large percentage of the "killed in battle" were cases where primary hæmorrhage followed the division of important vessels, death ensuing instantly, or before help could be procured.

Surgeon John A. Lidell, U. S. V., observes that a large proportion of the persons killed in battle perish directly from loss of blood. He examined the bodies of 43 dead soldiers, lying where they had fallen on the field of battle. Of these, 23 were wounded in the cranium, 15 in the thorax, and 5 in the abdomen. The blanched and exsanguinated appearance of the bodies wounded in the abdomen, showed clearly that death had been produced by hæmorrhage, and the extreme rapidity with which death had ensued implied that some large blood-vessel had been severed. In the cases wounded in the thorax the bodies also presented the same blanched appearance. There was much blood in the clothing and on the ground in most of the cases wounded in the trunk, showing that the fatal hæmorrhage had taken place externally. There were, however, some cases wherein death had been caused by internal hæmorrhage ; there was but little blood in their clothing or on the ground, but they presented the pallid, wax-like appearance common to death by bleeding. All the wounds appeared to have been inflicted by cylindro-conoidal bullets.

Primary hæmorrhage from wounded veins is generally regarded as of less imminent importance than that from wounded arteries ; but primary hæmorrhage from large trunk-veins lying in cavities and beyond the reach of ligation appears to be as fatal as that from arteries. Primary hæmorrhage from the jugular and femoral veins would appear to be less amenable to treatment than that from others which yield to pressure or cease spontaneously.

Early in the late war it was recommended that each soldier should have in his possession some simple form of tourniquet, and in many regiments the recommendation was carried out ; how far they were of use is not known, as no cases were reported of life having been saved by them ; but it is probable that they were little used, and it is very doubtful if, in the excitement and confusion of battle, they could have been applied with any efficacy. Later in the war, experience taught the older and more seasoned troops to do all that could be done in cases of emergency.

Of the many complications of shot wounds perhaps no one plays a more important part than hæmorrhage.

Injuries apparently trivial prove fatal in the most unexpected manner, as the lesion of the artery causes at first little or no disturbance ; or hæmorrhages occur in cases in which, judging from the course of the ball, no injury to a blood-vessel could have been surmised. Thus the prognosis of a shot wound becomes exceedingly problematical, and the surgeon, not infrequently, is suddenly roused from a feeling of security and brought face to face with an unexpected and serious complication, which, under the peculiar necessities of war, is of difficult treatment ; and the results thus far have been by no means so satisfactory as could be wished.

Too often the surgeon is induced to await developments rather than to resort to prompt action.

ARTERIES.—The number of arterial hæmorrhages found on the records of general and field hospitals, as having occurred during the late war, is 3,245. Of these bleedings 1,049 occurred in the lower extremities; 878 in the upper extremities; 291 were hæmorrhages of the head, face, and neck; and 497 of the trunk.

Of the 3,245 cases recorded the blood-vessels involved were not named in 1,010 instances; and as the details of these cases are not as complete as those of the remaining 2,235, in which the bleeding vessels were definitely ascertained, the former will be dropped in the further discussion of the subject.

The following table shows, first, the bleedings of the ramifications of the ascending aorta in the chest, neck, head, and upper extremities; next, those of the descending aorta in the abdomen, pelvis, and lower extremities; and lastly, the few cases of pulmonary hæmorrhages. The table also indicates the number of cases in which pyæmia, erysipelas, tetanus, and gangrene are reported as complications; the number of cases in which death was ascribed directly to hæmorrhage; and the proportion of cases in which primary injury to vessels and primary bleedings were observed.

Summary of Two Thousand Two Hundred and Thirty-five Cases of Arterial Hæmorrhages of the Head, Neck, Chest, Trunk, and Upper and Lower Extremities, in which the Bleeding Vessels were Indicated by Name.

Arteries	Cases.	Results.		[illegible]	[illegible]	Pyæmia.		Gangrene.		Erysipelas.		Tetanus.		[illegible]
		Rec.	Fat.			Rec.	Fat.	Rec.	Fat.	Rec.	Fat.	Rec.	Fat.	
Innominate	2		2											2
Carotid, common	96	21	75	11	6	—	1		2					41
External carotid	12	4	8	5	2	—				1				1
Superior thyroid	3	2	1			—								1
Lingual	7	4	3	5	1	—	1							
Facial	13	8	5	4		—								
Occipital	3	2	1	1	1	—								1
Temporal	30	24	6	6	6	—		1	1	1				1
[illegible]	21	12	9	4	1	1				1				6
[illegible]	2	2		1	1	—								
Internal maxillary	14	6	8	1	1	—								8
Middle meningeal	8	3	5	1		—								2
Internal carotid	11	2	9	2	1	—								5
[illegible]	1	1				—								
Subclavian	62	10	52	12	1	—	6	2	4	1	1			33
Vertebral	2		2	1		—								
[illegible]	1		1			—								
Internal mammary	9	2	7	1		—	1							
[illegible]	2		2			—								
Intercostal	37	11	26	7	4	—	2		1					13
Inferior thyroid	3	2	1			—								
[illegible]	1		1	1		—								
[illegible]	2	1	1			—								
Suprascapular	12	5	7	1		—								3
Axillary	87	11	76	26	4	—	1		6					38
[illegible]	10	1	9											
Subscapular	10	1	9				2							
Circumflex	32	20	12	1		1	2	1	1				1	2
[illegible]	2		2											
Brachial	261	102	159	77	22		25	17	11	7	1			
[illegible]	4	2	2				1							
[illegible]	14	8	6											
[illegible]	3	1	2				1							
Radial	111	76	35	32	5		1	1	1					
Radial and ulnar	1	1		1			2							
Ulnar	49	37	12	7	1		1	6	1					1
Interosseous	12	8	4	7	1		1		1					2
Palmar arch	23	16	7				2							
[illegible]	2	2												
[illegible]	1													
[illegible]	1	1												
[illegible]	11	8	2				1							
[illegible]	2		2	2										
[illegible]	1		1											
Hepatic	2		2	2										
Splenic	2		2	1										
Mesenteric	2		2	1	1									
[illegible]	1		1	1										
[illegible]	2	1	1				1							
[illegible]	7		7	2	1				1				1	
[illegible]	1		1	1										
[illegible]	1		1											
Gluteal	22	4	18	2	1		1		1					12
Sciatic	7		7	1					1					3
Pudic	3	1	2											
Hæmorrhoidal	1		1											
[illegible]	26	5	21	6			2		2					7
Epigastric	3	2	1	1										
[illegible]	1		1											
Femoral	561	119	442	100	27	2	45	11	35	1	1		1	[illegible]
[illegible]	1	1												
Profunda femoris	20	8	12	1			6	2	2					2
[illegible]	10	2	8				2							
[illegible]	7	4	3			1					1			
Perforating arteries	6		6				1							
Muscular branches	51	25	26	2			1	1	2	1				12
Popliteal	106	26	79	46	9		12	5	24	1				32
Articular arteries	8	4	4	1										
Tibial	270	128	142	76	14		29	10	28	1	1		1	46
[illegible]	2		2											
[illegible]	6	5	1											1
[illegible]	3	3												
[illegible]	8	6	2				1							2
[illegible]	2		2											
[illegible]	15	5	10	5	1		2	1	1				1	4
Pulmonary arteries	2		2	1	1									
Aggregates	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	177	80	148	25	10		11	[illegible]

The number of cases of primary lesions of blood vessels is quite large, comprising 485, or nearly one-fourth of the number under discussion. Of these 110 were immediately followed by hæmorrhage.

To what extent the injuries to arteries influenced the mortality-rate among the wounded will be seen from the fact that, of the 2,235 instances in which bleedings formed an important element, 1,380, or 61.7 per cent., proved fatal; while of the total number of shot wounds (245,790, see table supra) only 13.6 per cent. ended in death. Nor can this high mortality be attributed to the presence of other complications, as pyæmia, gangrene, tetanus, and erysipelas, as the fatality of the cases in which these diseases occurred comprised only 20.5 per cent. of the whole number of deaths; while in 653 instances, or 47.3 per cent., death was ascribed directly to hæmorrhages, and in 22.2 per cent. to exhaustion following severe or continuous loss of blood.

It will be found most convenient, in dealing with the cases of hæmorrhage, to classify them simply as primary and secondary. While, undoubtedly, some of these bleedings occurred a short time after the injury and before the period of suppuration had commenced, it is found impossible to eliminate these cases with certainty and accuracy; and inasmuch as such hæmorrhages partake more or less of a primary or secondary character, they have been assigned to one or the other of these groups.

The following table indicates the days on which hæmorrhage first occurred:

Table Indicating the Days on which the First Hæmorrhage Occurred.

Day after injury on which the hæmorrhage occurred.	Cases.	Head, chest, and upper extremities.	Abdomen, pelvis, and lower extremities.
1st day	153	68	85
2d day	17	5	12
3d day	17	6	11
4th day	26	17	9
5th day	24	15	9
6th day	37	22	15
7th day	62	36	26
8th day	58	34	24
9th day	68	35	33
10th day	71	37	34
11th day	71	44	27
12th day	68	43	25
13th day	64	33	31
14th day	52	30	22
15th day	51	36	15
16th day	40	21	19
17th day	41	20	21
18th day	39	24	15
19th day	33	19	14
20th day	20	9	11
21st day	35	23	12
22d day	34	16	18
23d day	28	17	11
24th day	23	15	8
25th day	14	6	8
26th day	20	13	7
27th day	13	8	5
28th day	17	12	5
29th day	13	8	5
30th day	5	3	2
31 to 40 days	102	51	51
41 to 50 days	57	25	32
51 to 60 days	40	15	25
61 to 70 days	21	6	15
71 to 80 days	10	1	9
81 to 90 days	8	3	5
91 to 100 days	6	..	6
Above 100 days	22	4	18
	1,480	780	700

The number of bleedings on the first day was 153, of which 110 were hæmorrhages immediately following the injury (strictly primary), while 43 occurred at some period within the first twenty-four hours succeeding the injury. If deemed desirable to make a group of intermediary cases, these forty-three cases, with those occurring on the second and third days, should probably be so classified. Those of the first day undoubtedly partook of the nature of primary hæmorrhage and were results of reaction; as to those of the second and third days, the data are insufficient to determine their proper classification. By the fourth day sufficient time had elapsed to allow such changes as result from inflammatory action, and which are recognized as productive of secondary hæmorrhage; and it will be noticed that from this day the bleedings perceptibly increase until the tenth and eleventh days, when the greatest number of hæmorrhages occurred. From this point their frequency gradually and somewhat regularly diminishes, until the thirtieth day; after this time they lose their regularity and occur at various intervals, subject to infectious diseases or other peculiar conditions attending each case. Examples of long-deferred hæmorrhage were not rare. In one recorded case it did not occur until the two hundred and sixty-fourth day; in another the first bleeding occurred on the one hundred and twenty-second day. In another instance—a case of sloughing after gunshot fracture of the humerus—it did not occur until the one hundred and twenty-ninth day, necessitating, at that late period, amputation of the arm.

Not infrequently the hæmorrhage following immediately upon the injury ceases spontaneously, only to return at a later period, generally in the evening or during the night, at times when the reactionary process is most pronounced. A soldier was wounded May 12, 1864; the ball entered right side of chest in front, near the armpit, fracturing in its course the right shoulder-blade at the middle. Secondary hæmorrhage occurred May 27th, to the extent of eight ounces, from the axillary artery. The fractured lower angle of the scapula was removed; the subscapular artery was found intact; an operation to ligate the axillary artery was therefore commenced, but the patient died before the operation was finished. His comrade said that hæmorrhage to the amount of a gallon or more occurred immediately after the reception of the wound, but that it had ceased spontaneously.

In several instances one or more slight bleedings—"warning bleedings"—preceded the actual hæmorrhage. A soldier of a South Carolina regiment was wounded in the upper part of the right femur, July 28, 1864; he was captured and taken to hospital at City Point. The fracture was high up and the femur was badly shattered; the limb was placed on an inclined plane and the fragments brought as nearly in apposition as possible; slight hæmorrhages took place on September 4th and 7th, which yielded readily to pressure; on September 8th a severe hæmorrhage occurred, exhausting in amount, and from which the patient sank rapidly and died the next day.

Instances of hæmorrhage from the distal end of arteries after ligation of the cardiac end are reported; there were also a few cases in which the bleeding occurred from the distal extremity of a wounded blood-vessel, as either primary or secondary hæmorrhage, before operative interference.

The form of hæmorrhage known as capillary or parenchymatous was occasionally seen, and was marked by a steady leakage of blood from the capillary vessels, often great in amount, and frequently resulting in syncope or exhaustion. The discharge had neither the bright scarlet of arterial, nor the darker hue of venous blood; it flowed without jets and was difficult to arrest. When observed as a primary condition, or after a primary operation, it was generally the result of what is known as the hæmorrhagic diathesis. In other cases it was due to paralysis of the capillary vessels from inflammatory action. It was most frequently noticed as an accompaniment of pyæmia and osteomyelitis, and was caused by interrupted venous circulation, assisted by the leucocythæmic condition of the blood in such cases.

Fifteen cases of this form of hæmorrhage are reported. In the cases of recovery the bleeding was comparatively slight and easily controlled by cold, compression, or styptics. Of the nine fatal cases, death occurred either as a direct result of the bleeding, or from the complications which probably gave rise to it, as pyæmia, gangrene, erysipelas, and diarrhœa. Of the fifteen cases capillary hæmorrhage followed amputation in seven instances—with three recoveries and four deaths; and ex-ration in six cases, with one recovery and five deaths. Four cases of secondary hæmorrhage are noted. Two, occurring from maxillary arteries of [illegible], were controlled by [illegible]. One appears to have been a case of recurring hæmorrhage from the medullary artery of the tibia of a patient whose [illegible] finally recovered. The fourth was a case of osteomyelitis of the tibia, and finally, complicated by diarrhœa, ultimately [illegible] in recovery.

Traumatic Aneurism.—In 74 cases the injuries were followed by traumatic aneurism. Twenty-three cases terminated in recovery and 51 in death, a mortality-rate of 68.9 per cent. Thirty-four, or nearly one-half of all the cases, were aneurisms of the femoral or axillary arteries—20 of the former and 14 of the latter.

The aneurisms were either diffused or circumscribed, and in one case time had been given for anastomotic communication. In one case recorded ligation of the subclavian had been performed for aneurism of the axillary artery; an aneurism again developed after his discharge from the service. The man is a pensioner, and the last report of his condition states that he now has aneurism involving the innominate artery; the thrill is very distinct, radial pulse cannot be felt, he suffers pain in the chest and is incapacitated for all labor.

Forty-two of the 74 cases were treated by ligation; of these, 13 recovered and 29 died. In one case of shot wound of the axillary region, unattended by fracture, an aneurism appeared three months after the injury, which increased very rapidly; the subclavian was ligated, but on opening the sac the tissues were found infiltrated with blood and disorganized, and the arm was amputated at the shoulder joint. The patient died in a few days from exhaustion.

Causes of Hæmorrhage.—The earlier cases of hæmorrhages are due to the force of the blood-current in the returning circulation during reaction; to commencing inflammatory action in which the swelling has been sufficient to force out the protecting coagulum; to weakened arterial walls, or finally to a depraved condition of the blood in persons suffering from exhausting or depressing diseases.

Not infrequently the hæmorrhage of the earlier days has its source in the injury of some vessel of considerable size, unnoticed in the primary examination of the wound. Cases are cited in which no excessive hæmorrhage had been noticed until attempts were made to effect the removal of a lodged missile or foreign body, which had prevented bleeding by acting as a plug or tampon.

Regarding secondary hæmorrhage in its usual acceptation, as embracing all cases of bleeding from wounded vessels occurring after the establishment of suppuration, including cases of rupture of the sacs of traumatic aneurisms, we find that by far the greater number is due to the separation of a slough, the result of a contusion of the walls of a vessel, and the inflammatory action consequent upon it.

The time required for this process varies within very wide limits, and appears to be dependent upon the size of the artery, the contusion, and somewhat upon its proximity to the heart. Ulcerative action extending from neighboring parts may attack a vessel, with similar results.

Scorbutic diathesis, fevers, gangrene, pyæmia, osteomyelitis, and all conditions which lower the vital forces or alter the elements of the blood, as well as the general condition of the patient and his physical health, largely influence this complication.

Hygienic surroundings must also be taken into consideration as playing an important part in the maintenance of good physical status and enabling the wounded man to successfully resist the insidious attacks of disease.

Thrombosis of veins will cause pressure on the arteries of wounded parts and reopen vessels temporarily closed.

Diseases of the coats of the arteries, as atheroma, etc., will hasten hæmorrhage, and in such cases the conditions will render operative interference doubtful and uncertain.

Transportation of the wounded during the process of suppuration has been mentioned as a cause of hæmorrhage by surgical writers, and cases recorded during the late war justify its enumeration as an exciting cause. A soldier suffering from a gunshot, compound fracture of the right knee-joint, after doing well for three weeks, was removed from hospital on the evacuation of the place; while being lifted into an ambulance wagon a sudden and uncontrollable hæmorrhage took place, which proved almost immediately fatal.

Accidental causes will be found to be not uncommon, as falling out of bed, the pulling away of ligatures during delirium, falling upon stumps, and spasmodic twitching of muscles.

Hæmorrhages subsequent to ligation may be due to the engorged condition of the vessels in the neighborhood of the injury, which were cut or injured during such operation.

Treatment.—Of the 2,235 cases of hæmorrhage, 294 were followed by amputation; 786 were treated by compression, styptics, etc., or ceased spontaneously; and in 1,155 cases the bleeding vessels were ligated.

Summary of Two Thousand Two Hundred and Thirty-five Cases of Hæmorrhage, Indicating Mode of Treatment.

Treatment.	Cases.	Recovered.	Died.	Percentage of fatality.
Hæmorrhage followed by amputation	294	122	172	58.5
Hæmorrhage ceased spontaneously, or was arrested by compression and styptics	786	[illegible]	[illegible]	[illegible]
Hæmorrhage treated by ligation	[illegible]	[illegible]	[illegible]	[illegible]
Hæmorrhage followed by ligation and subsequent amputation	[illegible]	[illegible]	[illegible]	[illegible]
Hæmorrhage from stump after amputation (ligated)	[illegible]	[illegible]	[illegible]	[illegible]
Aggregate	2,235	[illegible]	[illegible]	[illegible]

Amputation was resorted to for the purpose of saving life in cases of uncontrollable hæmorrhage, both primary and secondary. In primary bleeding, where the original injury was so far destructive to the parts as to render ligation unavailing; in secondary bleeding, in cases of traumatic aneurism, with great infiltration of tissue; in gangrene following division or ligation of the principal arteries; and in cases where ligation had failed to arrest bleeding, and where more radical measures were demanded to prevent a further loss of blood. Of 294 cases thus treated by amputation, 122 recovered, and 172 died, a fatality of 58.5 per cent.

Of the remaining 1,941 cases of hæmorrhage, 786 were treated by compression, styptics, etc. The fatality of these cases was large, exceeding that of ligation by 12.2, and that of ligation and subsequent amputation by 5.7 per cent.

In a number of cases digital compression was employed as a temporary measure, and in a few instances steadily continued compression appears to have been rewarded with favorable results. Generally the tourniquet was carefully and judiciously used, although, in a few instances, a resort to operative procedure would have been much better for the patient.

Cases of troublesome bleeding from the posterior auricular, occipital, or temporal arteries or their branches are reported to have been controlled by means of compression by a clamp, tourniquet, bandage and compress, or by a metallic disk acting as a compress. In one such instance transverse division of the wounded artery was sufficient to secure complete retraction of the ends.

No cases of acupressure, after the method of Sir James Y. Simpson, appear in the records, though it would seem probable that many wounds must have prosented themselves in which this measure would have been found convenient, speedy, and effectual.

Torsion was employed in a few recorded cases, and in one case the actual cautery was used to arrest troublesome bleeding.

Two cases of transfusion of blood are reported, one successful, the other unsuccessful.

Styptics were very commonly used, and were to be found in every knapsack and pannier; while it is possible that in many cases their use may have been ill-advised, and while it may be admitted that, in the hands of the timid or ignorant surgeon, they may furnish an excuse for procrastination or non-action in imperative cases, still, the evidence of their usefulness during the late war is not altogether unfavorable. The use of ice and cold was very general, and was very favorably regarded. Internal hæmostatics were used to some extent, but little can be said decisively in their favor from the records of cases in which they were used. Tannic and gallic acid and ergot were most generally used; these remedies were especially employed in cases where the vital powers were much depressed, and where the coagulative elements of the blood were deficient.

Ligations.—Of the 2,235 cases of hæmorrhage in which the bleeding vessels were specified, 1,155 were followed by ligation, embracing nearly all the principal arterial trunks and their branches. Of these, 471 recovered and 684 died. The fatality in these cases, as well as in the cases of hæmorrhage followed by amputation, was principally due to exhaustion following excessive loss of blood previous to the operation, to recurring hæmorrhages after operations, or to complications, such as gangrene, erysipelas, and especially pyæmia.

Five hundred and forty-one of these operations, with 292 recoveries, and 249 deaths, a mortality of 46.0 per cent., were performed in the upper circulatory system, and 614, with 435 deaths, a fatality of 70.8 per cent., in the lower circulation, thus confirming the general opinion that proximity to the centre of circulation favorably influences the final issue.

Three hundred and forty-eight were ligations after amputations; of these, 157, with 52 recoveries and 105 deaths, were ligations in the continuity of the stump, and 191, with 134 deaths, ligations on the face of the stump.

It is probable that the ligation in continuity was frequently the only alternative, and perhaps a greater saving of life would have resulted had the operation been more generally performed in the continuity, as bleedings from the stump were generally found in patients of low vitality, and where but little was to be expected from any operation in the immediate proximity to diseased tissue.

Of the remaining 807 cases, 236 were ligations in the wound, 5 ligations above and below the wound, and 413 ligations in continuity; in 153 instances the mode of ligation was not indicated.

Tabular Statement of One Thousand One Hundred and Fifty-five Ligations for Shot Injuries.

Arteries ligated.	Cases.	Results. Recovered.	Results. Fatal.
Common carotid	82	19	63
External carotid	7	4	3
Superior thyroid	1	1	..
Lingual	1	1	..
Occipital	5	4	1
Auricular	1	1	.
Temporal	18	14	4
Facial	8	5	3
Submental	1	1	...
Subclavian	51	10	41
Internal mammary	2	...	2
Intercostals	6	2	4
Thyroid axis	1	1	...
Superficial cervical	1	1	...
Supra-scapular	2	2	...
Axillary	49	7	42
Acromial thoracic (branch)	1	..	1
Subscapular	2	1	1
Circumflex	18	11	7
Muscular branch	1	..	1
Brachial	170	119	51
Muscular branch	3	1	2
Profunda	7	5	2
Anastomotica magna	1	...	1
Radial	59	45	14
Ulnar	22	20	2
Interosseous	9	6	3
Palmar arch	4	4	...
Dorsalis and radialis indices	2	2	...
Dorsalis carpi	1	1	...
Arch vol. profundi	1	1	...
Digital arteries	4	3	1
Common iliac	5	...	5
Internal iliac	3	...	3
Gluteal	6	2	4
Sciatic	2	.	2
External iliac	26	3	23
External spermatic	1	...	1
Femoral	374	93	281
External pudic	1	1	..
Profunda	22	5	17
Perforating arteries	6	...	6
Muscular branches	24	6	18
Popliteal	36	8	28
Articular arteries	3	1	2
Anterior and posterior tibial } 47	7	4	3
Anterior tibial }	40	22	18
Dorsalis pedis	1	1	...
Interosseous	2	1	1
Posterior tibial	48	29	19
Plantar arteries	3	2	1
Peroneal	4	1	3
Aggregates	1.155	471	684

It is probable that the large majority of ligations of the last group were operations in continuity.

The various modes of ligation, with their respective mortalities, are indicated in the following table:

Table Indicating the Various Modes of Ligation and their Fatality.

Arteries.	Total cases.	Ligations in continuity. Recovery.	Ligations in continuity. Fatal.	Ligations below and above wound. Recovery.	Ligations below and above wound. Fatal.	Ligations in wound. One end. Recovery.	Ligations in wound. One end. Fatal.	Ligations in wound. Both ends. Recovery.	Ligations in wound. Both ends. Fatal.	Ligations in wound. Not indicated. Recovery.	Ligations in wound. Not indicated. Fatal.	Mode of ligation not indicated. Recovery.	Mode of ligation not indicated. Fatal.	After amputation. In continuity. Recovery.	After amputation. In continuity. Fatal.	After amputation. On face of stump. Recovery.	After amputation. On face of stump. Fatal.
Carotids and branches	124	29	66	..	..	5	1	5	3	3	3	8	1	.	..	..	..
Subclavian and branches	63	5	29	..	..	4	4	2	1	..	..	1	1	4	12	..	..
Axillary and branches	71	5	17	..	..	3	2	3	4	2	3	3	9	2	10	1	7
Brachial and branches	181	66	17	1	1	5	2	17	6	3	3	15	10	9	10	9	7
Radial, ulnar and branches	102	11	2	3	..	9	4	22	5	12	1	14	4	4	3	7	1
Iliac and branches	43	2	24	..	..	2	1	.	..	.	..	.	8	..	5	1	..
Femoral and branches	427	28	91	..	..	1	10	6	23	2	5	14	28	33	64	21	161
Popliteal and branches	39	3	10	..	..	2	2	1	4	..	2	1	7	..	..	2	5
Tibial and branches	101	3	5	..	..	7	4	11	8	6	2	16	10	.	1	16	12
Peroneal	4	..	..	..	..	..	..	..	..	..	..	1	2	.	..	..	1
Aggregates	1,155	152	261	4	1	38	30	67	54	28	19	73	80	52	105	57	134
Percentages		63.1		20 0		44.1		44.6		40.4		52.2		66.8		70.1	

The fatality after ligations in continuity was 66.4 per cent.; after ligations in the wound, 39.9 per cent. The propriety of ligating both ends of a wounded artery was shown in numerous instances, and cannot be too strongly insisted upon.

Out of 410 ligations in continuity, 261 had fatal terminations, a mortality-rate of 64.1 per cent., largely exceeding the fatality of ligations in the wound; but it will be observed that, with the exception of the femoral, the larger vessels, as the carotid, subclavian, axillary, iliac, and popliteal arteries were, as a rule, tied in continuity. It is to be regretted that ligations of both ends in the wound had not been more generally practised.

Lidell records, as his personal observation after several severe battles, that he had not met with a single case of primary hemorrhage which required a surgical operation, such as the application of a ligature, for its suppression.

Neudörfer and Richter, experienced European military surgeons, have never been called upon to control primary hemorrhage after injuries of blood-vessels by ligation on the field of battle, at the first place of dressing; but a number of such operations were performed during the War of the Rebellion, and the result of these operations seems to have been quite successful. Thus, for instance, of thirteen ligations of the femoral performed on the battle-field, seven proved successful; of ten ligations of the tibial arteries, seven terminated in recovery; and of fourteen ligations of the brachial, only one had a fatal termination, although several of these cases were complicated by fractures.

VEINS.—Hemorrhage from wounded veins is generally regarded as of less practical importance than that from wounded arteries.

The record shows five instances of ligation of veins.

Summary of One Hundred and Six Cases of Hæmorrhage from Veins.

Veins.	Cases.	[illegible]		Causes of Death.					Ligation.		Remarks.
		Recovered.	Died.	Pyæmia.	[illegible]	[illegible]	Hemorrhage.	[illegible]	Recovered.	Fatal.	
Facial	1	1									
Temporal	1	1									
Longitudinal sinus	2	1	1	1							
Jugular, internal	15	1	14				8	5			1 [illegible]
Jugular, external	6	[illegible]	[illegible]	1			2				
Subclavian	[illegible]	1	2				2				
[illegible]	2		2				2				
[illegible]	2	1	1			1			1		
[illegible]	1	1									
[illegible]	1		1				1				1 [illegible]
[illegible]	1		1				1				1 [illegible]
[illegible]	2	1	1				1				
[illegible]	1		1	1							
[illegible]	2		2				2				
Femoral	15	2	13	[illegible]	1		7		1		1 [illegible]
Saphenous	6	1	5	1	1		1	1		1	1 [illegible]
[illegible]	2		2				2				
[illegible]	1	1							1		[illegible]
[illegible]	7	3	4	1			[illegible]				
[illegible]	[illegible]	1	[illegible]	1							
[illegible]	17	1	16	[illegible]			6	1			1 [illegible]
[illegible]	7		7				4	2		1	1 [illegible]
Totals	106	20	86	17	5	1	57	6	3	2	

From the number of venous vessels, and from the fact that they are less liable to evade a missile than arteries, it would seem that injuries of veins should have been more frequently noted.

Statistics on the relative frequency of injuries of the arteries and veins are nowhere found in treatises on military surgery. Richter suspects that many soldiers perish on the battle-field from injuries of these vessels.

It remains a fact, however, that hemorrhages from veins came far more rarely under the observation of the surgeon than those of arteries; but that their fatality is equally as great, if not greater, than that of arteries, is clearly proven by the above tabular statement.

Secondary hemorrhage from veins occurred at irregular periods of from one to seventy days; in one instance the bleeding did not take place until the one hundred and thirty-second day; and in another, a case of shot wound of the buttock, uncontrollable venous hemorrhage occurred from a persistent fistula, three years after the injury.

Two cases of death are ascribed to the sudden entrance of air into veins; in a third case the subclavian vein was accidentally cut while searching for the axillary artery; the entrance of air caused syncope, and death ensued in less than ten minutes.

TETANUS.—Considering the number of injuries recorded during the late civil war, the proportion of cases of tetanus is not large: of the 246,712 injuries by weapons of war, 505 (0.2 per cent., or a little over two in a thousand) were followed by tetanus.

In the cases in which this complication was observed, the seat of injury was: in the head, face, and neck in 21 instances; in the trunk in 45; in the upper extremities in 147; and in the lower extremities in 292 instances.

The preponderating frequency of tetanus in the lower extremities, observed by Beck and others, was very marked, over one-half of all the cases having occurred after injuries in this portion of the human structure, due undoubtedly to the massive layers of muscles and soft tissue, which prevent the surgeon frequently from clearing the track of the wound of foreign bodies and other obnoxious influences.

Of the 292 cases of tetanus in the lower extremities, the injuries were in the hip in 2 instances, in the thigh in 99, in the knee in 17, in the leg in 95, in the ankle in 22, and in the foot in 57 instances; of the 147 cases in the upper extremities, the injuries were in the hand in 47, in the arm in 34, in the shoulder in 31, in the forearm in 24, in the elbow in 7, and in the wrist in 4 instances.

The belief that shot wounds of the hand and feet are particularly apt to cause tetanus is not confirmed by this summary. In 131 instances tetanus followed closely upon operations in the extremities, viz.: in 116 cases after amputation, and in 15 cases after excision.

The rarity of tetanus as a complication of chest wounds was especially marked.

The recoveries after tetanus appear to have chiefly occurred in cases of slighter or localized forms, or in those in which the disease took a chronic course; and it is possible that the early application of powerful narcotics interrupted the progress of the malady in a few acute cases.

It may be considered that the later the occurrence of the disease after an injury, the better is the chance of recovery ; and also, that the longer the duration of the affection after its inception, the greater is the chance of life.

In the following table are indicated the days after the injury or after amputation on which tetanus made its appearance :

Statement Indicating the Day after Injury or Amputation on which Tetanus Appeared.

Cases.	Days after the Injury of Amputation on which Tetanus appeared.																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 to 30	Above 30
367	27	8	9	9	19	30	23	37	24	27	25	20	17	12	6	7	11	5	4	4	3	1	3	3	3	7	23

In 27 cases tetanus appeared on the first day ; but 21 of these were cases of tetanus following amputation, so that in reality it only appeared in 6 cases within the first twenty-four hours after the original injury ; and it may be here stated that, with the exception of a small number of cases, tetanus in cases of amputation invariably followed within a few days after the operation. Few cases occurred on the second, third, and fourth days after injury ; but from the fifth day, when sufficient time had elapsed for inflammatory action to establish itself, the number of cases rapidly increased until the eighth, when it gradually diminished again until the fourteenth, after which period it appeared irregularly, in one instance the malady not making its appearance until seven months after the injury.

As causes of this fatal malady are cited : excessive heat, exposure to cold and damp air, draughts, neglect of thorough and early cleaning of the wound channel, pressure of missiles and bone splinters and of bandages on nerves, injuries to nerves while searching for foreign bodies, or while performing ligations and excisions.

The duration of the disease is indicated in three hundred and fifty-eight cases, of which twenty-one ended in recovery, and three hundred and thirty-seven in death, as follows :

Numerical Statement of Results of Three Hundred and Fifty-eight Cases of Tetanus, in which the Duration of the Disease was Reported.

Result.	Totals.	Days of Duration of Tetanus.																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	21	23	24	26	27	29	33	37	39	48	49
Recoveries	21	1	1	..	..	...	...	...	...	1	1	1	...	...	2	...	1	...	...	1	3	2	1	..	...	1	1	1	1	1	1
Deaths	337	69	83	49	31	22	19	14	7	5	6	8	3	2	3	4	...	4	1	3	1	...	...	1	2	...	...	...	...	...	...
	358	70	84	49	31	22	19	14	7	6	7	9	3	2	5	4	1	4	1	4	4	2	1	1	2	1	1	1	1	1	1

In two hundred and three, or more than one-half of the cases in which this point was ascertained, the duration of the disease did not exceed three days, and of these only two recovered. In the remaining nineteen cases of recovery, the disease lasted from nine to forty-nine days, while the longest duration in the fatal cases was only twenty-seven days.

In several cases, the removal of a missile or foreign body, as pieces of bone, seems to have quieted the threatening symptoms ; in one instance they were relieved by the loosening of a bandage pressing on the brachial plexus, and in another by the removal of a neuroma. In one case an incision down to the nerve temporarily relieved the symptoms of trismus caused by the contraction of a cicatrix ; as the symptoms reappeared with increased vehemence, a portion of the nerve was dissected out, and no relief being afforded, amputation remained as the only recourse ; the patient finally recovered.

Including the case just referred to, amputation was resorted to in twenty-nine instances after incipient tetanic symptoms ; ten of the cases resulted favorably, and in several instances it is noted that the symptoms ceased after the operation.

The treatment was empirical to the last degree, and the formidable list of remedial agents employed in combating it presents a curious study of the diverse pathological and therapeutical views entertained by the medical profession on this subject.

In the cases of recovery, it is impossible to say how far any individual remedy or class of remedies was of avail : chloroform, ether, opiates, stimulants, and external irritants, embrocations, and fomentations were mainly relied on.

In some instances the symptoms disappeared so speedily and permanently as to raise the question whether the same result might not have occurred spontaneously. In the fully developed cases all remedial measures failed, and the cases ran on to a fatal termination.

Sixteen, or 3.1 per cent of the five hundred and five instances of tetanus were found among the colored troops, who furnished 2.7 per cent. of the total number of shot injuries.

GANGRENE.—In studying the records of the war, it has been found impossible to classify with accuracy the cases reported as traumatic gangrene, dry gangrene, hospital gangrene, etc., as these terms seem to have been used in many instances indiscriminately, according to the views or predilection of the surgeon ; all these cases, reported to have been observed as the results of, or following, shot injuries, will, therefore, be treated under the common head of gangrene.

The total number of cases reported as occurring during the late civil war, was 2,642. Of these 60 were observed after wounds of the head, 216 after wounds of the trunk, and 2,366 after wounds of the extremities, as follows :

Summary of Two Thousand Six Hundred and Forty-two Cases of Gangrene, Indicating the Result and Relative Frequency.

Seat of injury.	Recovery.	Fatal.	Undetermined.	Total.	Per cent. of fatality.	Per cent. of relative frequency.
Flesh wounds of head, face, and neck	5	7	....	12	58.3	60 = 2.2
Fractures and penetrating wounds of head, face, and neck	32	16	....	48	33.3	
Flesh wounds of trunk	36	32	7	75	47.0	216 = 8.2
Fractures and penetrating wounds of trunk	44	97	....	141	68.7	
Flesh wounds of the upper extremities	47	50	12	109	51.5	2,366 = 89.6
Fractures of the upper extremities	476	245	14	735	33.9	
Flesh wounds of the lower extremities	125	127	92	344	50.3	
Fractures of the lower extremities	596	568	14	1,178	48.7	
Aggregates	1,361	1,142	139	2,642	45.6	

Thus it will appear that 89.6 per cent. of all the cases of gangrene were observed in wounds of the extremities, 8.4 per cent. in wounds of the trunk, and only 2.2 per cent. in wounds of the head, face, and neck, although it has been previously shown that the proportional injuries for the three regions is 70.88 per cent. for the extremities, 18.37 per cent. for the trunk, and 10.77 per cent. for the head, face, and neck. Nearly two-thirds of all the cases of gangrene occurring in the lower extremities.

The results in 139 of the 2,642 cases of gangrene were not ascertained; 1,361 terminated in recovery, and 1,142 in death, a mortality-rate of 45.6 per cent. But in a large number of these cases death was ascribed either to the injury itself, or to other complications—traumatic hemorrhage, exhaustion, pyæmia, erysipelas, pneumonia, typhoid fever, diarrhœa, and other diseases. With the exception of the penetrating wounds of the trunk, the percentage of fatality of cases of gangrene after flesh wounds is larger than that after fractures. In wounds of the trunk alone, the mortality of the fractures and penetrations exceeds that of the flesh wounds, the former being 68.7, the latter 47.0 per cent.

Of the 2,366 instances of gangrene in the extremities, 185 were cases of gangrene following excisions, and in 46 of these cases amputation of the limb had to be resorted to. In 898 instances gangrene was noted on the face of the stump. In a few of the cases the complication was caused by strangulation of the stump by tourniquet.

But the large majority of the cases were instances of hospital gangrene, caused by the crowded condition of the hospitals and the bringing together of many cases of extensive fractures and large operation-wounds.

How far the frequency of the occurrence of gangrene was influenced by the seasons of the year cannot be ascertained from the reports; it can only be stated that the highest number of cases was observed in June, July, August, May, and December; the lowest in February and March.

Only four cases of gangrene were recorded for the first eight months of the war, in 1861, but it must be remembered that the medical and surgical reports for this period are very incomplete. In the following year, 1862, the number of cases increased to two hundred and twenty-three. A few sporadic cases occurred in the hospital at Fort Hamilton, N. Y., in the month of September, among men wounded in McClellan's peninsular campaign in June and July. Of the three cases reported at that hospital, one at least was that of a soldier who had been carried to Richmond, and had then been paroled.

It was after the great battles of South Mountain and Antietam, in September, 1862, that serious outbreaks of hospital gangrene occurred at the hospitals at Frederick, Md., and at West Philadelphia.

The next appearance of the disease, more serious in character than that observed at Frederick and West Philadelphia, was at Annapolis, Md. It appears that in January, 1863, one hundred and fifty-three patients were brought to Annapolis from Richmond. Very many of these men were wounded, and all had been closely confined in the prisons and in the prison hospitals of that city. Of these men four had hospital gangrene at the time of admission to hospital at Annapolis, and thirty-one contracted the disease within a short time. On January 29th four hundred and twenty-one additional patients were admitted from the same place and under the same circumstances; of these gangrene existed in fourteen at the time of their admission.

By February 7th the number of affected patients amounted to sixty. All cases in which the process of destruction was advancing, or in which separation and granulation had not fairly set in, were collected in special wards isolated from all other buildings, and special bedding, blankets, utensils, sponges, supplies, dressings, and instruments were provided for them. The disease from this time remained almost entirely confined to the paroled prisoners. It was evident that the origin of the disease had been due to their close confinement in the Libby prison at Richmond and the adjacent hospitals. In these places all the conditions were present for engendering the disease—close confinement in crowded, unventilated rooms, bad feeding and dressings, and foul and unsanitary surroundings.

The paroled prisoners who had been captured on the Western battle-fields referred the development of their gangrene to tedious and painful transportation from the West to Richmond. The cars were closely boxed, the food was deficient and bad, and all opportunities for cleanliness were absent. The spread of the disease at Annapolis was unmistakably by contagion.

Cases which occurred at Nashville, Tenn., where the disease appeared a month or so later, were undoubtedly of indigenous origin. Thirty-eight cases occurred in one hospital within a few days, and the results of an examination made as to its origin offer striking examples of the methods of the production of gangrene, by the use of buildings constructed in utter disregard of all sanitary laws.

In February, 1863, a few cases appeared at the Douglas Hospital, Washington, D. C., in the persons of soldiers wounded at the battle of Fredericksburg, Va. The largest number of cases of gangrene (1,611) occurred in 1864, when the terrible battles of Grant in Virginia, and of Sherman in Georgia, filled the hospitals to overflowing; but the disease seems to have lost its terrors to medical officers. The cases were promptly isolated in hospitals or wards especially assigned for the purpose, and under various forms of treatment the larger proportion of cases were brought to a successful termination. The proportion of cases of gangrene to the number of troops engaged, or to the wounded treated in hospitals during the six months of 1865, was very small; only one hundred and thirty-five being recorded upon hospital registers.

Instances of dry gangrene, the result of shot injuries, were rare; nine cases are noted; in all these cases the feet or the toes were the parts affected. Interference with the arterial circulation was the cause of the gangrene, although the manner of the interference is not clear in one or two of the cases. In five of the nine cases of dry gangrene cited amputation was performed after the appearance of the disease; four recovered. The remaining four cases, in which no operative interference was resorted to, proved fatal.

The treatment of gangrene as carried out in the military hospitals consisted in facilitating and hastening the removal of the sloughs, thoroughly cleansing and keeping in a healthy condition the open wound, limiting the extension of the ulcerative action, and the administration of tonics, stimulants, and supporting and nutritive food, with the endeavor to build up the debilitated system. Locally the gangrenous ulcers were treated by applications of fuming nitric acid to the edges of the sore, to its surface, and to the healthy integument beyond the line of diseased action; also by the use of nitrate of silver, Labarraque's solution, and stimulating poultices of yeast, cinchona, and charcoal.

In the West the use of bromine as suggested by Dr. M. Goldsmith was extensively used and with undoubted good effect. It was applied in full strength by means of little swabs, after a thorough cleansing of the wound and the removal of all gangrenous and diseased tissue; the wounds were kept carefully closed from exposure to the air, were closely watched, and upon the slightest reappearance of the disease the process was repeated.

In the use of these agents, nitric acid, bromine, iodine, acetic acid, and Labarraque's solution, now well understood to be potent germicides, we see the foreshadowing of the present antiseptic treatment of wounds.

Dr. Goldsmith claimed for bromine prophylactic virtues which seem to have been in a degree substantiated. Under the present methods of antiseptic surgery, with the advanced knowledge and practice of hygiene and sanitation, it is doubtful if hospital gangrene will ever again prove to be the scourge of armies that it has been in the past.

TRAUMATIC ERYSIPELAS.—Wherever large numbers of wounded are collected together, there is always a liability to invasions of this complicating disease.

During the late war, the instances of traumatic erysipelas were much less frequent than those of hospital gangrene. Under the head of traumatic erysipelas, as occurring in groups of shot wounds, we must consider all cases in which inflammation of the skin originating from a wound quickly extends over the surrounding parts, ending in rapid resorption, while the process is accompanied by exceedingly high fever.

The total number of cases of this affection, as recorded during the war, is 1,097, or only 0.4 per thousand of all cases of wounds. Its regional distribution is shown by the following table:

Numerical Statement of One Thousand and Ninety-seven Cases of Traumatic Erysipelas.

Seat of Injury.	Cases.	Recovery.	Fatal.	Undetermined.	Regional percentage.
Head, face, and neck	154	107	44	3	14.0
Trunk	57	23	33	1	5 2
Upper extremities	457	259	180	18	41.7
Lower extremities	429	229	193	7	39.1
Aggregates	1,097	618	450	29	

The average duration of the disease was eleven days; in 31.7 per cent. it subsided in from one to five days, in 31.7 per cent. in from six to ten days, in 19.4 per cent. in from eleven to fifteen days, and in 17.2 per cent. the duration of the disease exceeded fifteen days.

A first attack of erysipelas by no means secured a patient against a second, and, as a rule, it would seem that the later attacks were the more virulent. One patient is recorded as having had nine separate attacks, and many others more than one.

Generally the disease confines itself to the parts first infected, and thence extends in a centrifugal manner, showing that, as Socin expressed it, "the matter causing the inflammation spreads itself abroad more by the way of imbibition than in the direction of the larger venous and lymphatic vessels." However, swellings and abscesses in the axillary and inguinal regions are not infrequent. Sometimes the disease spreads itself over the neighboring parts and affects nearly the whole body. Cases are on file in which the disease made its appearance in the head, and extended down the neck and chest to the pelvis; or in which it originated in a wound of the hand and spread over the arm and trunk, and even the face; or where it first showed itself in the toes and attacked the leg, thigh, and lower part of the trunk.

Four hundred and fifty of the 1,097 cases of erysipelas proved fatal, a mortality-rate of 41.0 per cent. In sixty cases the death was ascribed to pyæmia, in eight to gangrene, in five to tetanus, in twelve to hæmorrhage, and in sixty-six to other diseases. In one hundred and sixty-eight instances only was the fatal issue directly attributed to erysipelas, making a fatality of 15.3 per cent. in the total number of cases.

Erysipelas made its appearance under apparently the most favorable hygienic conditions. It was observed, however, that the disease prevailed less extensively in tents than in hospital buildings.

Generally, the disease occurred in crowded hospitals with illy ventilated rooms, and rapidly spread from one patient to another.

Erysipelas was noted in 452 cases of amputation, and in 106 excisions; of the 452 cases of amputation, the disease occurred in 151 instances before, and in 301 after the operation; of the 106 cases of excision, the affection made its appearance in all but four cases after the operation; and here it is proper to note the liability of this operation to the complication of erysipelas.

The disease was most frequently observed in periods in which the number of wounded patients was the largest; the same may be said of the season of the year, although it was generally more prevalent in cold and damp seasons, and at times when it was necessary to keep the doors and windows of hospital buildings closed.

The wounded among the colored troops seem to have been seldom affected by this disease, as only eleven are reported as having been attacked by it; but five of the eleven cases proved fatal, four from erysipelas and one from pleuritis and erysipelas.

The treatment of this affection consisted in completely isolating the patient; in a large majority of cases the disease yielded to the topical application of tincture of iodine or solution of creasote; the internal treatment most generally employed was moderate doses of the tincture of the muriate of iron, frequently repeated, quinine, and good diet. The use of bromine in the form of vapor to the affected part, as well as the direct application of the drug, was enthusiastically advocated by Dr. Goldsmith and others.

PYÆMIA.—The total number of cases of pyæmia observed after shot wounds, in the late war, was 2,818, of which 71 recovered, and 2,747 died; a mortality-rate of 97.4 per cent. In 21 only, of the total of fatal cases, were other causes than pyæmia mentioned as having influenced the fatal issue, viz., hæmorrhage, gangrene, tetanus, erysipelas, peritonitis, and typhoid pneumonia. In all of the large remainder of fatal cases, pyæmia was the only cause of death ascribed.

Whether in cases attacked by the disease the wounds were in the head, the face, the neck, the trunk, or the extremities; whether the injuries were flesh wounds or accompanied by fracture; or whether they were treated conservatively or by operation, seemed immaterial; all were alike fatal.

Summary of Two Thousand Eight Hundred and Eighteen Cases of Pyæmia, Indicating Location of Injury and Result.

Seat of Injury.		Cases.	Recoveries.	Deaths.	Death-rate.
Head, face, and neck...		66	3	63	95.4
Chest, abdomen, and pelvis		270	8	262	97 0
Upper extremities ..	Conservation	338	8	330	97 6
	Excision	165	3	162	98.2
	Amputation .	415	9	406	97 8
Lower extremities ..	Conservation	709	24	685	96 6
	Excision	55	2	53	96.3
	Amputation .	800	14	786	98 2
Aggregates		2,818	71	2,747	97.4

Over one-half of all the cases of pyæmia were found after wounds of the lower extremities; in 86,413 injuries of this class, 1,564 or 18.1 per thousand cases of pyæmia were reported; of 87,793 injuries of the upper extremities, 918 or 10.4 per thousand; of 45,184 injuries of the trunk, 270 or 5.9 per thousand; and of 26,400 injuries of the head, face, and neck, 66 or 2.5 per thousand were followed by this complication.

In the 1,721 cases, the days of appearance of the pyæmic symptoms after the injury were noted as follows: On the

2d day in 5 cases.
3d day in 6 cases.
4th day in 13 cases.
5th day in 16 cases.
6th day in 17 cases.
7th day in 24 cases.
8th day in 29 cases.
9th day in 38 cases.
10th day in 37 cases.
11th day in 37 cases.
12th day in 50 cases.
13th day in 59 cases.
14th day in 54 cases.
15th day in 60 cases.
16th day in 76 cases.
17th day in 68 cases.
18th day in 70 cases.
19th day in 66 cases.
20th day in 65 cases.
21st day in 56 cases.
22d day in 55 cases.
23d day in 42 cases.
24th day in 40 cases.
25th day in 42 cases.
26th day in 50 cases.
27th day in 31 cases.
28th day in 36 cases.
29th day in 31 cases.
30th day in 20 cases.
31st to 35th day in 135 cases.
35th to 40th day in 89 cases.
41st to 45th day in 55 cases.
46th to 50th day in 42 cases.
51st to 100th day in 151 cases.
101st to 150th day in 30 cases.
151st to 200th day in 8 cases.
201st to 250th day in 9 cases.
251st to 300th day in 5 cases.
Above 300th day in 4 cases.

1,721 cases.

From the second day after the injury the number of cases gradually and almost regularly increased until the sixteenth day, on which the highest total, viz., 76, is recorded. From the seventeenth to the thirtieth day after the injury the number decreased; after that period the disease appeared at various intervals, in some instances as late as two hundred and three hundred days; and in one case, a case of recovery, the pyæmic infection was ascribed to a wound over four and a half years after the injury.

The duration of the pyæmia, from the day on which the first symptoms were observed to the day of death, was reported in 1,687 cases.

The deaths occurred on the

1st day in 71 cases.
2d day in 96 cases.
3d day in 172 cases.
4th day in 171 cases.
5th day in 204 cases.
6th day in 161 cases.
7th day in 148 cases.
8th day in 123 cases.
9th day in 92 cases.
10th day in 81 cases.
11th day in 64 cases.
12th day in 59 cases.
13th day in 41 cases.
14th day in 29 cases.
15th day in 34 cases.
16th day in 17 cases.
17th day in 21 cases.
18th day in 14 cases.
19th day in 12 cases.
20th day in 15 cases.
21st to 25th day in 35 cases.
26th to 30th day in 18 cases.
31st to 35th day in 12 cases.
36th to 40th day in 11 cases.
41st to 45th day in 3 cases.
46th to 50th day in 1 case.
Above 50th day in 5 cases.

About two-thirds of the cases died within the first seven days; the largest number of cases was recorded on the fifth day. In 81 only of the total number did the patients survive the twentieth day after the appearance of the disease.

Traumatic pyæmia was seldom noticed unless the bony structure was injured. Of the 165,821 wounds without lesions of bone, only 564, or 3.4 per thousand, were followed by pyæmia; while of the 79,969 shot fractures, 2,254, or 28.1 per thousand, were followed by this complication.

Very little is to be said of the treatment of pyæmia; tonics, stimulants, and a supporting diet were given, but, as has already been seen, with very little effect, as 97.4 per cent. of all the cases proved fatal. In the early stages of the disease, quinine in large doses would reduce the temperature, but the improvement seemed to be only temporary unless the treatment was continued for some time, which, unfortunately, the patients were unable to bear.

In wounds of extremities amputation has been recommended for the removal of the infection when first observed, but even this extreme remedy seemed to be of little avail. Three or four cases are reported in which limbs were removed while the patients were in a pyæmic condition, and from the successful issue of these particular cases, it may be presumed that the removal of the infectious focus had a beneficial influence.

Climatic, Hygienic, and Moral Influences, as Affecting Shot Wounds and Injuries.—Of the effects of climate on the treatment and result of wounds, but little information is to be obtained from the reports of the war; casual remarks were occasionally made by medical officers, that in certain climates and localities wounds "did well" or otherwise, but so vague a statement is of little value, as it is more than probable that insufficient consideration was given to other closely related conditions which may have exerted a stronger influence than climate.

The change of climatic conditions experienced by our troops during the operations of war, in a sudden transition from the cool and healthful regions of the North to the warm, semi-tropical, and malarial regions of the South, could not fail to make itself felt on the general economy, aside from any of the contingent exposures, hardships, or privations incident to a soldier's life.

The health, vigor, and efficiency of the troops campaigning in some parts of the South, were undoubtedly impaired by climatic causes, and it is fair to presume that under the conditions so acquired wounds and surgical diseases suffered a corresponding modification.

Putting aside the consideration of other factors, it would seem that continuous dry heat is not unfavorable to the satisfactory progress of gunshot wounds; the same may be said of the same quality of cold—both, probably, acting as tonics to the system at large. Moist climates, with continuous heat, are recognized as enervating and weakening, rendering the body less capable of resisting the onset of prevailing diseases.

It has been claimed that the moist, warm climate of parts of the southern seaboard was exceedingly favorable to the healing process of wounds. It may be that the especial qualities of sea air afforded a favorable element.

The pure, bracing air of the highlands of Virginia, Tennessee, and Georgia was unquestionably especially favorable to the recovery of the wounded. The very successful results of wounds and operations during General Sherman's campaign from Atlanta to the sea was especially marked, though it must be admitted that very important factors other than that of climate had their full influence upon the men of that command.

Sudden and extreme variations of temperature and humidity were prejudicial to the favorable course of wounds, and seemed especially to favor the spread of tetanus.

Prolonged cold and moisture were generally regarded as tending to excite surgical complications, as erysipelas and gangrene, though here the probable explanation may be that these diseases were engendered by the want of free ventilation at these times.

The subject may be briefly summed up in the statement that those conditions of climate, wherever found, which allow the fullest and freest exposure to pure, fresh air are those most favorable to the rapid and uncomplicated recovery from wounds; while such conditions as tend to prevent a free, natural interchange, or compel the exclusion of large quantities of fresh air from the wards of hospitals, and from barracks and tents, or such as favor the rapid decomposition of vegetable and animal matter, are to be considered as prejudicial and harmful to the course and treatment of wounds. The influences of hygienic condition, food, and concurrent diseases upon the results of shot injuries in time of war are similar to those observed in cases treated in time of peace in civil hospitals.

The influence of mental condition on the results of wounds is noteworthy. All reports agree that the wounded of victorious armies, cheered by the successes achieved by their own bravery and that of their comrades, did better than those of defeated armies. The most striking example of this influence of mental condition on wounds in modern times is the fearful mortality among the French, after shot wounds of all kinds, in the war of 1870–71. The excessive mortality of that campaign was, undoubtedly, largely owing to the mental depression caused by a succession of reverses rarely met with in the history of warfare.

CONSERVATION, EXCISION, AMPUTATION.—The shot wounds of the extremities numbered 174,200, or over two-thirds of the whole number of shot injuries. Of these 140,124 were treated without operative interference, 4,656 were followed by excision, and 29,420 by amputation.

To the cases of amputation should be added 305 amputations following excisions and 240 re-amputations, bringing the total number of amputations to 29,965.

Eighty-seven thousand seven hundred and twenty-three, with 80,680 recoveries, 5,608 deaths, and 1,435 unknown results (a mortality rate of 6.5 per cent.), were shot injuries of the upper extremities. Of these, 32,902 were wounds complicated by fracture, and 54,821 were flesh wounds; of the latter, 87 were followed by amputation. Of the 32,902 shot fractures of the upper extremities, 3,841, or 11.6 per cent., were followed by excision; 15,707, or 47.7 per cent., by amputation; and 13,415, or 40.7 per cent., were treated without operative interference, beyond the removal of missiles, bone splinters, or other foreign substances.

Eighty-six thousand four hundred and thirteen were shot injuries of the lower extremities; the results were not ascertained in 935 cases; 73,665 resulted in recovery, and 11,813 in death—a fatality rate of 13.8 per cent.

Fifty-nine thousand one hundred and thirty-nine were flesh wounds, of which 201 were followed by amputation.

Twenty-seven thousand two hundred and seventy-four were shot injuries involving the bones of the lower extremities; of these, 815, or three per cent., were treated by excision, 13,466, or 49.1 per cent., by amputation, and 13,053, or 47.9 per cent., without operative interference.

In the upper extremities, 11.6 per cent. of the total number of fractures were treated by excision; in the lower extremities only three per cent. There is little difference in the relative percentage of amputation in the upper and lower extremities (in the first 47.7 per cent., in the second, 49.1 per cent.); the proportion of cases of conservative treatment in the lower extremities exceeded that in the upper by 7.2 per cent., being 47.9 in the former and 40.7 per cent. in the latter. It is difficult to account for this larger percentage in the attempts at conservation in shot fractures of the lower extremities, unless it be due to the instruction given by the medical directors of the armies, that amputation in the thigh should not be performed on the battle-field, and that by the time the patient reached a general hospital the favorable time for operation had passed. It is a curious anomaly that in the upper extremity conservatism was more extensively employed in the part most distant from the trunk, while in the lower extremity the reverse was the case. Of 8,245 shot fractures of the humerus, 2,960, or 35.9 per cent., and of 5,194 shot fractures of the bones of the forearm, 2,971, or 57.2 per cent., were treated by conservative measures throughout. In the lower extremities, the percentage of cases of fracture of the femur treated conservatively exceeded that of the fractures of the leg; in the former, 3,620 out of 6,738, or 53.7 per cent., being treated without operative interference; in the latter, 4,116 out of 9,171, or 44.8 per cent.

One hundred and thirteen thousand nine hundred and forty shot flesh wounds of the extremities, including cases of injuries of arteries and nerves, in which no lesions of bone were reported, gave 4,560 fatal results, a mortality of forty per cent.; of these 54,801 of the upper extremities, with 1,640 deaths, gave a mortality-rate of 2.9 per cent.; and 59,139 of the lower extremities, with 2,920 deaths, a fatality-rate of 4.9 per cent. Of the former in 82, and of the latter in 201 cases, amputation was resorted to, generally on account of hæmorrhage, aneurism, or extended sloughing or suppuration; less frequently on account of pyæmia, gangrene, and erysipelas; and in a few instances on account of laceration of nerves.

Sixty thousand two hundred and sixty-six of the 174,206 shot wounds of the extremities were complicated by injuries of the bony structure. Forty-four thousand three hundred and seventy-five recovered, 12,861 proved fatal, and the result in 3,030 cases was not recorded, a mortality-rate of 22.4 per cent. Thirty-two thousand nine hundred and ninety-two were fractures in the upper, and 27,274 in the lower extremities.

Summary of Sixty Thousand Two Hundred and Sixty-six Shot Fractures of the Extremities, Showing Treatment and Results.

Mode of Treatment.	Cases.	Recovery.	Fatal.	Undetermined.	Percentage of fatality.	Upper Extremities.				Lower Extremities.			
						Recovery.	Fatal.	Undetermined.	Percent. of fatality.	Recovery.	Fatal.	Undetermined.	Percent. of fatality.
Conservation	26,467	20,854	4,562	1,051	17.9	11,646	1,288	480	9.9	9,208	3,274	571	26.2
Excision	4,656	3,183	1,213	260	27.5	2,714	858	239	23.8	439	355	21	41.7
Amputation	29,143	20,338	7,086	1,719	25.8	12,539	1,822	1,376	12.6	7,799	5,264	343	40.2
Aggregates	60,266	44,375	12,861	3,030	22.4	26,929	3,968	2,095	12.8	17,446	8,893	935	33.7

The greatest fatality after shot injuries of the extremities, with lesions of the bone, was observed in shot wounds of the hip-joint, where the fatality reached 84.7 per cent. Next came injuries of the knee-joint, with a mortality of 53.7 per cent.; then those of the thigh, of which 52.4 perished. Injuries of the shoulder-joint gave 34.2 per cent. mortality; of the leg, 27.0; the ankle-joint, 26.9; the arm, 20.7; the elbow, 19.4; forearm, 9.4; foot, 8.3; and finally injuries of the bony structure of the hand, 3.1 per cent. fatality. The percentage of recoveries attending attempts at conservation was quite flattering, but it must be borne in mind that the cases reported as treated conservatively were cases selected as specially adapted to this mode of treatment, and probably were the least serious.

The disposition to conservation developed itself rapidly as medical officers became familiar with serious cases of shot injuries, and it is safe to say that, in the later stages of the war, many limbs were saved which at an earlier period would have been sacrificed; especially was this the case in the upper extremities, where the preservation of the hand, or even portions of the same, was considered most important for the good of the individual.

Probably, the least satisfactory ultimate results of conservative treatment were those on the foot and ankle, which, while successful in saving life, rendered it doubtful, in the light of their ultimate condition, whether conservation was the wisest course.

Excisions.—Of 4,656 excisions, 3,841, or over four-fifths, were in the upper extremities, and 815 in the lower extremities.

The excisions at the hip-joint lead with the largest mortality, 90.9 per cent.; next, excisions at the knee-joint, with 81.4 per cent.; those of the shaft of the femur show a fatality of 69.4 per cent.; of the shoulder, 36.6 per cent.; of the ankle-joint, 29.0 per cent.; of the shaft of the humerus, 28.6 per cent.; in the tibia and fibula, 28.2 per cent.; in the bones of the foot, 19.3 per cent.; at the wrist-joint, 13.8 per cent.; forearm, 11.3 per cent.; and bones of the hand, 9.6 per cent.

With the exception of the elbow, the excisions in the joints show larger mortality-rates than those in the osseous structure above the joints; the fatality of the operations in the knee-joint exceeds that in the shaft of the femur 12.0 per cent.; in the ankle-joint the fatality is 0.8 per cent. greater than in the leg; and in the wrist-joint 2.5 per cent. greater than in the bones of the forearm. The excisions at the elbow-joint, on the contrary, show more favorable results than those of the arm, the death-rate being 5.6 per cent. less in the former than in the latter. The percentage of fatality in the entire series of excisions of the extremities is disappointing, especially when it is considered that over four-fifths of the excisions were performed in the upper extremities, where the chances for success must be considered the brightest. It disproves the opinion held by the advocates of this operation, that excision involves less loss of life than amputation. That it might be possible to obtain better results in well-appointed hospitals, constructed in accord with the sanitary knowledge of the day, is not denied; and the many excellent results now obtained in conservative surgery in civil practice, under the advantages of the present antiseptic treatment of wounds, should encourage the military surgeon to persevere in his efforts in this direction.

In brief, it may be stated that the results after excision in the long bones and in the knee- and ankle-joints were little less than disastrous, and the ultimate condition of many of these cases, although considered successful shortly after the operation, proved to be deplorable.

Numerical Statement of Four Thousand Six Hundred and Fifty-six Excisions in the Extremities.

Seat of operation.	Cases.					Primary.				Intermediary.				Secondary.				[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shoulder joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shaft of humerus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Elbow joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wrist joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bones of hand	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hip joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shaft of femur	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Knee joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tibia and fibula	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ankle joint	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bones of foot	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aggregates	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
						[illegible]				[illegible]				[illegible]				[illegible]			

AMPUTATIONS.—The total number of amputations reported on the records of the war is 29,980; but the whole number of amputations performed for injuries received during the war would undoubtedly exceed that number. During the first eighteen months of the strife the reports of operations are very meagre. Of the 29,980 amputations, the results were ascertained in all but 1,719, as shown in following table:

Tabular Statement of Twenty-nine Thousand Nine Hundred and Eighty Amputations, Indicating Seat of Operations and Results.

Amputations.	Cases.				
	Total.	Recovered.	Died.	Results not ascertained.	Percentage of fatality.
Upper extremities:					
Amputations of the hand or fingers	7,902	6,541	198	1,163	2.9
Amputations of the wrist joint	68	60	7	1	10.4
Amputations in the forearm	1,761	1,505	245	11	14.0
Amputations at the elbow joint	[illegible]	[illegible]	[illegible]	1	7.6
Amputations in the upper arm	[illegible]	[illegible]	1,273	[illegible]	23.8
Amputations at the shoulder joint	866	596	245	25	29.1
Lower extremities:					
Amputations of the foot or toes	1,519	1,337	81	101	5.7
Amputations at the ankle joint	161	119	40	2	25.1
Amputations in the leg	[illegible]	[illegible]	[illegible]	168	33.2
Amputations at the knee joint	195	82	111	2	57.5
Amputations in the thigh	6,369	2,878	3,411	80	54.2
Amputations at the hip joint	66	11	55		83.3
Aggregates	29,980	20,802	7,459	1,719	26.3

As in excisions, the operations at the hip give the highest rate of mortality, 83.3 per cent.; next come amputations through the knee-joint, with 57.5 per cent.; those of the thigh, with 54.2 per cent.; of the leg, with 33.2 per cent.; of the shoulder joint, with 29.1 per cent.; of the ankle-joint, with 25.1 per cent.; of the arm, with 23.8 per cent.; of the forearm, with 14.0 per cent.; of the wrist, with 10.4 per cent.; of the elbow, with 7.6 per cent.; of the foot, with 5.7 per cent.; and of the hand, with 2.9 per cent.

It will be noticed that, with the exception of the amputations at the elbow and those at the knee-joint, the ratio of mortality in the upper extremities as well as in the lower, decreases with the increasing distance of the situation from the trunk. No sufficient reason can be assigned for the exceptionally favorable results in amputations at the elbow, while the gravity of injuries as well as of operations at the knee is well known. Comparing the mortality-rate after amputations with that of excisions in the same portion of the extremities, we find the following results:

Table Indicating Rate of Mortality after Amputations and Excisions in the Extremities.

Seat of operation.	Rates of mortality after	
	Amputation.	Excision.
Upper extremities:		
Hand and fingers	2.9	[illegible]
Wrist-joint	10.4	[illegible]
Forearm	14.0	[illegible]
Elbow	7.6	[illegible]
Arm	23.8	[illegible]
Shoulder	29.1	[illegible]
Lower extremities:		
Foot and toes	5.7	[illegible]
Ankle-joint	25.1	[illegible]
Leg	33.2	[illegible]
Knee-joint	57.5	[illegible]
Thigh	54.2	[illegible]
Hip-joint	83.3	[illegible]

With the exception of the operations in the bones of the forearm and those in the bones of the leg, the excisions are uniformly followed by larger percentages of fatality than the amputations, the excisions of the knee-joint especially showing an exceedingly large excess in the mortality-rate over the amputations at the knee. The favorable results after excisions in the bones of the forearm and leg are due to the fact that in many of these cases only portions of one or the other of the two bones comprising them were excised, thus lowering considerably the percentage of fatality of the operation. All operations performed within forty-eight hours after the injury have been considered and grouped as primary, as the commencement of inflammatory symptoms rarely falls within this period. In the amputations of the hip-joint alone, the primary period has been restricted to twenty-four hours, as it is believed that in these cases the inflammatory period is hastened by the gravity of the injury. In the second or intermediary group have been placed the cases in which the operation was performed in the interval from the third to the thirtieth day (both inclusive) after the injury; this class consists mainly of the operations performed during the inflammatory stage. The third group comprises the operations performed after the thirtieth day from the date of the injury, or at a period when the inflammation has abated or entirely subsided.

Of the 29,980 amputations the date after the injury on which operations were performed was recorded in 23,993 cases; of these the results were not ascertained in 231, leaving 23,762 cases in which the results as well as the dates of operation were recorded.

Summary of Twenty-three Thousand Seven Hundred and Sixty-two Amputations, Indicating the Period of the Operation.

Seat.	Cases.			Primary.			Intermediary.			Secondary.		
	Total.	Recoveries.	Fatal.	Recoveries.	Fatal.	Percentage of fatality.	Recoveries.	Fatal.	Percentage of fatality.	Recoveries.	Fatal.	Percentage of fatality.
Upper extremities:												
Amputations of hand or fingers	4,501	4,412	89	3,179	48	1.4	1,059	41	3.7	174	.	..
Amputations at wrist-joint	67	60	7	50	5	9.0	6	1	14.2	4	1	20.0
Amputations in forearm	1,655	1,420	235	911	97	10.6	350	109	23.7	159	29	15.4
Amputations at elbow	35	33	2	27	1	3.5	5		....	1	1	50.0
Amputations in arm	4,626	3,581	1,045	2,659	603	18.4	615	320	34.2	307	122	28.4
Amputations at shoulder	722	505	217	369	117	24.0	86	78	47.5	50	22	30.5
Lower extremities:												
Amputations of foot or toes	1,045	987	58	651	36	5.2	243	20	7.6	93	2	2.1
Amputations at ankle-joint	153	115	38	78	23	22.7	25	14	35.8	12	1	7.6
Amputations in leg	4,900	3,350	1,550	2,309	1,032	30.8	690	382	35.6	351	136	27.9
Amputations at knee-joint	189	79	110	50	57	53.2	16	37	69.8	13	16	55.1
Amputations in thigh	5,803	2,715	3,088	1,960	1,951	49.8	488	893	64.6	267	244	47.7
Amputations at hip-joint	66	11	55	3	22	88.0	...	23	100.0	8	10	55.5
Total	23,762	17,268	6,494	12,246	3,992	23.9	3,583	1,918	34.8	1,439	584	28.8
Aggregates				16,238			5,501			2,023		

Primary operations were the rule, over two-thirds of all the amputations belonging to this group. In the field, where few of the appliances of conservative surgery could be had, and where, moreover, the chances of properly applying them were uncertain; where, furthermore, transportation for considerable distance was unavoidable, amputation became necessary, when attempts at conservation might be made in a general hospital.

Primary operations give the best chance of life; those performed during the inflammatory or intermediary period are the most unfavorable in their results; the experience with intermediary operations was so discouraging, that when the time for primary operation had passed the operation was deferred, if possible, until the inflammation had subsided and the lesions had become local and analogous to chronic disease.

Of the different modes of operation, each method had its advocates; but the flap operations were more frequently used, especially in amputations near the joints. Of 11,053 cases of major amputations, in which the method is specified, 6,240 were flap and 4,813 circular operations. A multitude of varieties of the flap were recorded; instances have been cited of the use of the anterior, posterior, antero-posterior, lateral, bilateral, external, internal, oval, circular, U-shaped, rectangular, and skin or muscular flap. As far as stumps are concerned, handsome rounded ones were achieved by each method, and conical stumps were noted after the circular as well as after the flap operation.

The side upon which the operation was performed was recorded in 18,718 cases. The amputations on the left side exceeded those on the right by 3.4 per cent. Whether the seat of injury was on the right or left side seems to have had no influence upon the ratio of mortality.

The number of double operations performed on account of shot injuries was 172; of these, both upper extremities were amputated in 47, one upper and one lower in 43, and both lower in 82, as follows:

Numerical Statement of One Hundred and Seventy-two Cases of Double Amputations for Shot Injuries.

Extremity.	Total cases.	Recoveries.	Fatal.	Undetermined.	Percentage of fatality.
Both amputations in the upper extremities	47	31	16	..	34.0
One amputation in upper, one in lower extremities	43	21	21	1	50.0
Both amputations in the lower extremities	82	31	50	1	61.7
Aggregates	172	83	87	2	51.1

The mortality-rate of the cases in which both the upper members were removed is 34.0 per cent.; of those in which one of the upper and one of the lower extremities were amputated, 50.0 per cent., and of those in which the two operations were performed in the lower members, 61.7 per cent. *David L. Huntington.*

WRIST, JOINTS OF THE. The skeleton of the wrist, being a series of small bones essentially similar in character, may be considered as a whole, and we may hence conceive a superior radio-carpal or wrist-joint proper, between the bones of the forearm and the carpus, and an inferior or carpo-metacarpal joint, between the carpus and the metacarpus. Again, we may consider separately the two rows of carpal bones, and regard the somewhat irregular union between them as an intracarpal or medio-carpal joint. Finally, we may consider each bone as a separate unit and its union with each of those which it touches as so many carpal joints of a secondary degree.

Of the three transverse joints formed by the rows of carpal bones, the upper one is the only one that has any very marked mobility, the middle one has somewhat less, and the lower or carpo-metacarpal joint has the least of all. It is, indeed, instructive and logical in regarding the movements to follow the plan adopted by Meyer, and consider the lower row of bones as combined for practical purposes with the metacarpal bones with which they articulate and the upper row as an articular integer or meniscus which is the essential interposed element between the forearm and the hand. Viewing the form of the surfaces, the articulation between the meniscus and the forearm is a pommel or ellipsoidal joint. Movement is necessarily freest in the direction of the axes of the ellipsoid, but still a certain amount of rotation is possible. The surfaces involved are those of the triangular cartilage and the radius above, and the scaphoid, semilunar, and cuneiform below. The ulna does not enter into the articulation, nor does the pisiform bone. Many comparative anatomists are of the opinion that the triangular fibro-cartilage represents a carpal element which in its complete form long ago vanished from the mammalian carpus and that the pisiform bone is another vestige of the same kind. Certain facts of abnormal variation seem to support this view and to show that the pentadactylate form of the human hand is not the primitive form, firmly fixed though it now is, but that a seven-digit hand was probably the original mammalian type. Odd cases of supernumerary wrist-bones and fingers, which are occasionally seen, are, according to this view, instances of atavism.

The mid-carpal joint is of a mixed character, having, like the mid-tarsal joint of the foot, a wavy outline, the comparatively large, convex upper surfaces of the os

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[1] Medical and Surgical History of the War of the Rebellion.

magnum and unciform bones making together a sort of ball-like head which fits into the hollow socket made by the under surface of the conjoined scaphoid, semilunar, and cuneiform bones; while a comparatively small surface of the scaphoid articulates with the trapezium and trapezoid to make a curve in the opposite direction. This assists considerably in twisting movements of the hand, such as pronation and supination, which are very necessary to that nicety in the management of tools which characterizes the hand of man. The hand of the ape is by no means so delicately adjusted in this particular.

It has been well pointed out by Professor Humphry, in his classical treatise on the "Human Skeleton," that the wrist owes the security of its position not so much to the interlocking shape of the joint surfaces, or to the strength of its ligaments, as to the strong tendons which pass over it, tend to protect it and render it at the same time flexible. A short examination of the lower end of the radius will show that its dorsal aspect is deeply grooved for the extensor tendons which pass in every direction over the back of the hand. They are bound closely down in their grooves by a strong band of fascia called the posterior annular ligament, which thus becomes, as it were, one of the most powerful protecting ligaments of the radio-carpal joint. In a similar manner the anterior surface of the wrist is hollowed out by a deep archway, the carpal canal, so called because it is spread over by strong bands of fascia which confine the flexor tendons in a sort of subway.

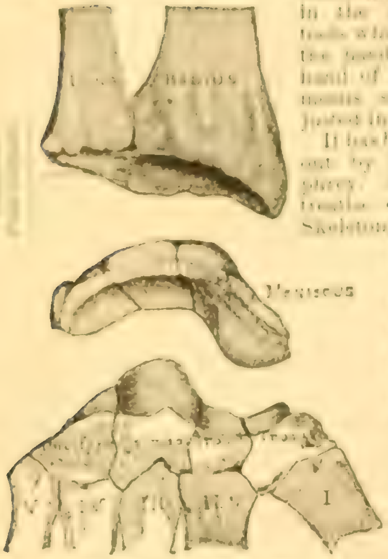

FIG. [illegible].—The Wrist-joints.

English anatomists group these bands together indiscriminately as the anterior annular ligament, but there can readily be distinguished two bands—a superficial one, to which the name of annular ligament may properly be applied, as it is a process of the deep fascia of the arm which passes over the tendon of the palmaris longus and the ulnar vessels and nerve, being continuous with the posterior annular ligament at either side; the second is more independent, partaking more of the nature of a ligament, and therefore properly designated as the ligamentum carpi volare proprium. It is a strong, firm band, attached on either side to the carpal eminences—that is to say, the pisiform and unciform bones on the inner side and the tubercle of the scaphoid and the ridge of the trapezium on the outer side. It passes under the tendon of the palmaris longus and the ulnar vessels and nerve. Beneath it pass the great flexor tendons and the median nerve, confined by several strong sheaths which blend with each other and send fascial processes to the ligament above and the attachments of the carpal bones below. It is to this arrangement, combined with protection, that we owe the surprising flexibility which characterizes the wrist, a flexibility which permits the extraordinary twists so famous in the pitching of a ball, the handling of a tennis racket, and the parrying of the thrust of a foil.

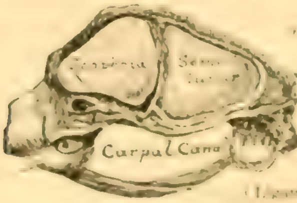

FIG. [illegible].—The Carpal Canal.

Viewing the wrist-joint with reference to its synovial cavities, we find that the radio-carpal joint has its own cavity, the mid-carpal and carpo-metacarpal having a common cavity, there being excluded two bones, the pisiform and the metacarpal bone of the thumb, each of which has its own special articulation—the first with the cuneiform, the second with the trapezium.

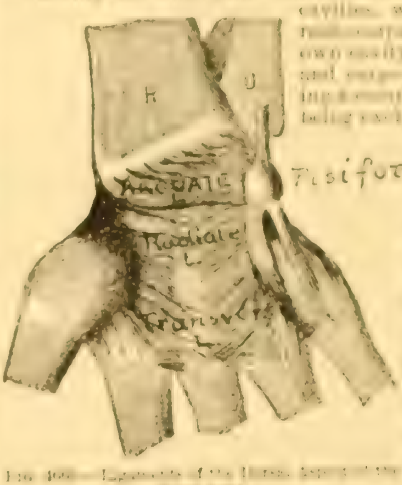

FIG. [illegible].—Ligaments of the Hand. Aspect of the Wrist-joint.

The intrinsic ligaments of the carpus are of two classes: one being external strengthening bands, the others internal, interosseous, serving as these interties to keep the whole system firm. On the palmar surface a somewhat irregular mass of fibres stretching from the bones of the forearm to the metacarpal bones, has received the name of the ligamentum carpi volare profundum.

Separate portions of this have received different names. Thus the arcuate ligament is that portion which passes downward and inward from the radius to the cuneiform bone; the straight ligament (ligamentum carpi rectum) is a rounded fasciculus that passes from the styloid process of the ulna to the semilunar and cuneiform bones, and the funiculus ligamentosus a similar one extending from the same to the cuneiform and pisiform bones. Bands from the pisiform bone to the unciform and to the fifth metacarpal (lig. piso-hamatum, lig. piso-metacarpeum) are considered as extensions of the insertion of the flexor carpi ulnaris. A series of short bands connecting the os magnum with the contiguous bones is known as the radiate ligament. Finally the most distal band, connecting the bases of the metacarpal bones, is known as the deep transverse ligament. All these divisions seem hardly necessary.

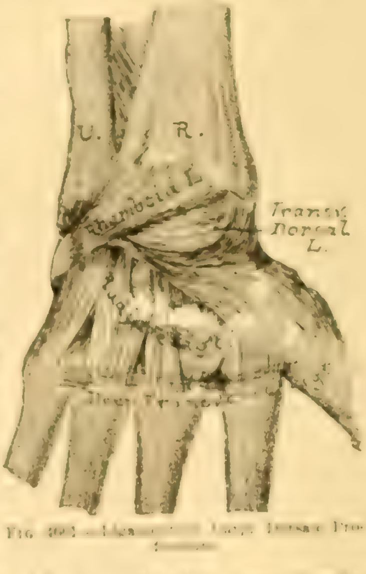

FIG. [illegible].—Ligamentum Carpi Dorsale Profundum.

The investment on the dorsal surface is not usually so complete. The strengthening bands are mainly two—the rhomboid ligament, passing downward and inward from the lower end of the radius to the cuneiform and unciform bones, and the transverse dorsal ligament, extending from the scaphoid outward to the same. There is also a dorsal radiate ligament diverging from the os magnum.

The only other joint requiring especial mention is that of the metacarpal bone of the thumb with the trapezium. This is an excellent example of the joint by reciprocal reception, sometimes termed the saddle-joint. Its motions are freest in two directions, which correspond to the motions of adduction and abduction on the one hand, and of the various adjustments of opposition on the other. *Frank Baker.*

XANTHOMA. Xanthoma, or xanthelasma, as it is sometimes called, is one of the benign new-formations of the skin. It has at different times received the names *fibroma lipomatodes*, *vitiligoidea*, and *molluscum cholestérique*. Rayer, of Paris, first described the affection, with the title *Plaques jaunâtres des paupières*. The new-growth is one of connective tissue, and while it has a decided predilection for the upper eyelids, the yellow, or buff-colored nodules of which the patch is composed may form upon various other portions of the body. I have seen it affecting several other regions, and Bulkley, Hardaway, Robinson, Barlow, Hyde, and others have recently reported cases in which the disease appeared upon the extremities and trunk. It often occurs about the elbows and knees, but rarely unless the eyelids are at the same time affected.

Varieties.—There are two forms in which the disease occurs, *xanthoma planum*, and *xanthoma tuberosum*.

The plane variety consists of plates or patches of yellowish or chamois-skin-like tissue situated in the corium, and projecting but slightly if at all above the skin level. The patches are, for the most part, small, smooth, and soft, with well-defined borders, and are usually elongated or oval. The color may vary from a creamy-white to a bronze, or an orange-yellow, and upon the eyelids the patches may have an arched configuration. In the beginning the lesion has only the size of a pin's head, but this is added to gradually, until after several years of slow growth one or more good-sized patches are formed. These are mostly found upon the upper lid, more seldom upon the lower, and at times in the skin surrounding the eye. Sometimes patches are found upon the body when none exist or have existed upon the lids. Dr. Robinson showed such a case several years ago at the New York Dermatological Society, and Hyde had an illustration of a case in which the knees and elbows were alone affected, in the *Journal of Cutaneous and Genito-Urinary Diseases* of 1887.

Xanthoma tuberosum differs from the preceding variety in that it occurs as papules, or tubercles, varying from the size of a pin's head to that of a bean, isolated or aggregated into plaques. The lesions are more elevated, more firm to the touch, and more likely to occur on other parts than upon the eyelids. Both forms may, however, coexist, and patches of the plane xanthoma may show tuberous elevations.

Xanthoma Multiplex.—In this rare form the lesions are scattered over the body, invading the face, flexures of joints, soles, palms, possibly the genital organs, and also mucous membranes, as the tongue (see article Tongue, Diseases of the). It has in one instance been known to rapidly spread over the whole body.

Symptoms are almost wholly wanting. In the usual course of the disease yellowish macules are first noticed upon the upper lid, near the external or internal canthus, and spreading occurs without subjective manifestations. In the tubercular form there may be some pain, and this has been especially noted when the palms and soles were involved. In xanthoma multiplex there is often much itching of the skin, even in the absence of jaundice.

Etiology.—Xanthoma is more frequent in women than in men. It is not usually met with before middle life, though occasional cases in quite young subjects have been recorded.

Nothing definite has been discovered in regard to the true cause of the condition. Heredity has been shown, by Church and others, to play a part in certain forms of the disease. Many cases are associated with jaundice and disorders of the liver, and while some observers have considered the jaundice to be a secondary condition due to the xanthomatous disease of the liver or bile-ducts, others have regarded it as causative. In thirty cases collected by Hebra and Kaposi, icterus was present in fifteen. Murchison and others have believed the circulation of bile-pigment in the blood to be an etiological factor. I have seen xanthoma in diabetic subjects, and it is said to be quite frequent in this disease. Hutchinson has shown its pathological relation with icterus and arthritis.

In 1883 Balzer described microbes found in the granular matter of the excised tumors, but so far as I am aware, they have never been proven to bear a causative relation to the affection. Balzer was led to seek a parasitic origin for the disease from the analogy which exists between it and tuberculosis, lepra, etc.

Jaundice in many cases first shows itself long after the xanthoma lesions, and in many cases is wholly absent, as are also all signs of liver derangement.

Pathology.—Though all observers are not in strict accord, it is now generally agreed that xanthoma consists of a connective-tissue new-growth. Robinson states that connective tissue forms the basis of the tumor, in which fatty degeneration readily occurs. Some observers have found the changes in the skin identical with those found in the early stages of atheroma. Pye Smith says "young leucocytes never form true tissue elements, molecular fatty degeneration rapidly overtaking them, and leading to their ultimate disappearance in a detritus of oil-drops, calcareous masses, and cholesterine crystals." Instead of following this course, which he designates the inflammatory type of the disease, the new cells may grow to a considerable size, and form fusiform and stellate corpuscles of connective tissue. Fatty degeneration may occur in this form as well, but is here a much slower process.

Diagnosis.—The only disease at all likely to be mistaken for xanthoma is that known as milium. The distinction is not difficult, though the situation of the lesion and the gross appearances when milium papules are aggregated may be quite similar in the two diseases. Pressing out the contents of the milium papules shows at once the nature of the affection.

Prognosis.—Some cases spontaneously recover, but this is as rare as it is a fortunate occurrence, and one not likely to be looked for. Degeneration into malignant growth has never been observed. Most cases last many years or during one's whole life, unless actively treated.

Treatment.—Excision, carefully done to avoid ectropion, when the eyelids are affected, offers the best means of removing the growth. This operation is often resorted to for cosmetic effect. The dermal curette has been advocated by some.

Co-existing disorders, such as disease of the liver, diabetes, etc., should be discovered and treated.

I have seen one case, in a woman with diabetes, where the xanthoma diminished as the diabetes improved. The use of phosphorus followed by turpentine has, according to Besnier, produced rapid disappearance of the tubercles.

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Charles W. Allen.

XERODERMA PIGMENTOSUM. The name "xeroderma" is one of those formerly given to the milder form of ichthyosis, but of late years it has been used in connection with the qualification "pigmentosum," to designate a peculiar and rare affection first described by Hebra and Kaposi, of Vienna, and recently thoroughly investigated by R. W. Taylor, of New York.

The affection is characterized by the appearance of minute telangiectases, pigmentations, and atrophic changes, all of which bear the most intimate pathological relations. Superadded to these polymorphous lesions there are others in the shape of new growths, which are at first of a benign nature and may thus remain, or may degenerate into malignant growths.

The disease in most cases begins in infancy, though some two or three doubtful cases are said to have begun in early adult life.

The invasion of the disease is very constant, beginning about the face or under the eyes as a well-marked, smooth, superficial erythema, which is often regarded as the result of sunburn. The patient's health remains good while the erythematous patches extend, coalesce, and gradually creep over the face and neck, usually stopping at about the third rib by an abrupt margin. This condition of the face, neck, and trunk is of variable duration—from one to several months—during which the erythema may become less red. As this preliminary hyperæmia disappears, pigmented and red spots, or telangiectases, make their appearance, scattered irregularly over the affected regions, becoming fully developed over the face and neck in about six months. In Taylor's opinion, the pigmented spots follow and result from the telangiectatic lesions, though J. C. White and Duhring deny this relationship.

The course of the disease, though varying from time to time, tends to pass from bad to worse, until, as the child grows older, the disfigurement becomes very marked. The maximum of pigmentation is reached in early childhood. After the fifteenth or sixteenth year the pigmented lesions rarely appear in such profusion as in the early years.

These two orders of lesions—the telangiectases and the pigmentations—are peculiar to the early stages of the disease. Later—beginning, however, in some cases as early as the end of the first year after the appearance of the morbid lesions, atrophy begins to show itself, sometimes slight, at other times extensive and deep. Upon the face this form of atrophy reduces the skin to the thinness of parchment, and destroys nearly all of the follicles, producing at times great disfigurement. It may occur elsewhere, especially, as upon the knuckles, at points subject to tension.

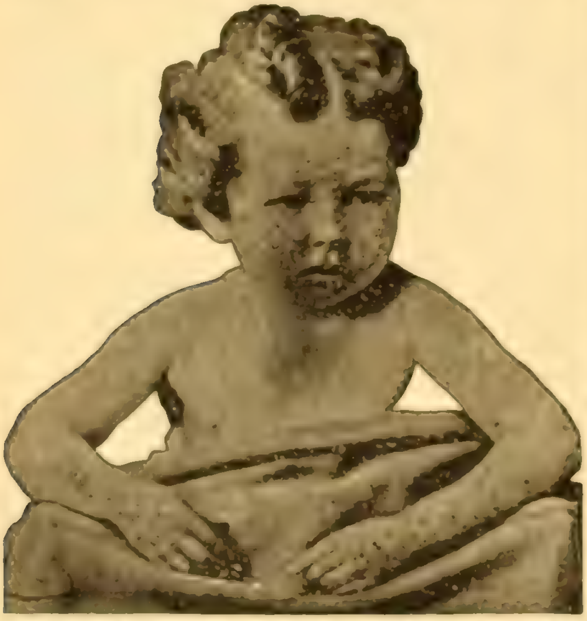
FIG. 4992.—Xeroderma Pigmentosum in a Child Three Years of Age. (Taylor.)

In almost all cases, particularly in those in which the pigmentations are deep and extensive, hypertrophic changes take place, very often coincidently with the atrophic processes, forming epithelial new growths. These may at first resemble keratosis senilis, but in some cases, especially about the muco-cutaneous junctures of the head, sessile or pedunculated, more or less elevated tumors form, with a tendency to increase in size and take on a fungating form. At first these tumors are of a deep-red or purple-blue color, soft, and compressible. They frequently become pale, less vascular, and so brittle and friable that they fall off, leaving sometimes a surface which heals spontaneously, or an ulcer which may be very intractable, extending in depth and breadth, and becoming frequently surrounded by thickened and everted edges, which may become the seat of malignant degeneration. The latter is, in some cases, epithelioma, in others melanotic sarcoma, sarcocarcinoma, or cancer.

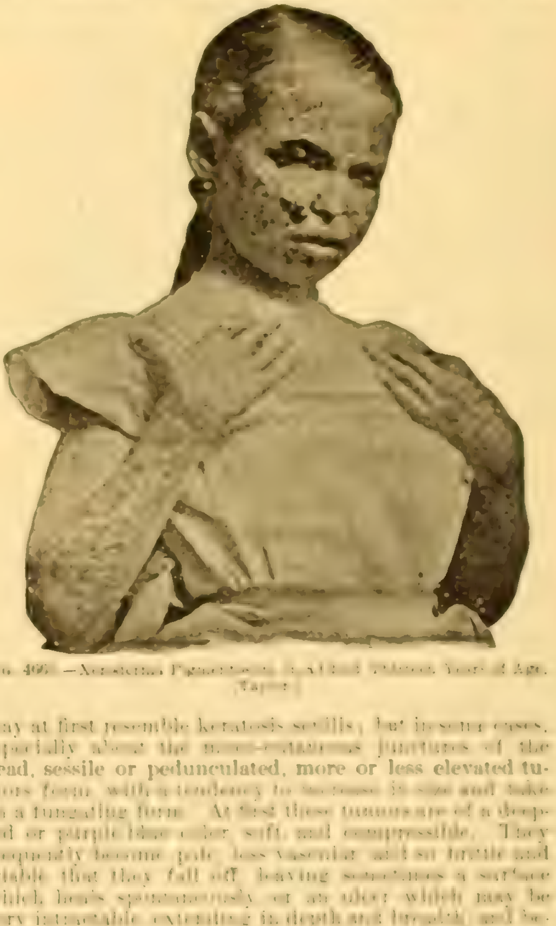
FIG. 4993.—Xeroderma Pigmentosum in a Girl Fifteen Years of Age. (Taylor.)

The treatment of xeroderma is exceedingly unsatisfactory. No case has ever been cured. The skin should be placed at rest, and all external sources of irritation should be avoided. All tumors, small and large, should be removed as soon as they make their appearance; and this is particularly necessary around the eyes, nose, mouth, etc., where malignant degeneration may be expected.

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Arthur Van Harlingen.

XYLOL. A hydrocarbon, or mixture of isomeric hydrocarbons of the composition $C_6H_4(CH_3)_2$, occurs as a constituent of coal tar, and is known as *xylol* or *xylene*. This substance is principally *metaxylene* (*metadimethylbenzene*), with a certain proportion of *paraxylene* (*paradimethylbenzene*), and possibly some other hydrocarbons. Pure metaxylene can be obtained by special processes. Xylol is a thin, colorless fluid of a faint odor, reminding somewhat of that of benzene, and of a burning taste. It is insoluble in water, but soluble in alcohol. Medicinally, xylol has been used in the treatment of small-pox, and had at one time an ephemeral, but undeserved, reputation as a remedy for the disease. It was administered internally in doses of from ten to fifteen drops, in emulsion, and was also applied locally to the throat. It is now practically obsolete as a medicine.

Edward Curtis.

YARROW (*Millfoil; Millefeuille*, Codex Med.), *Achillea millefolium*; Order *Compositæ*. This is a very familiar plant, both in Europe and America. Its half-domesticated way of growing in old pastures, waysides, and gardens in this country makes it seem like an introduced herb. It has a perennial root, from which arise one or more, often several or many, upright simple stems a foot or eighteen inches high, leaves narrow, twice pinnately parted, with linear divisions also cleft or gashed inflorescence, a flat-topped compound corymb, of many small heads of white flowers. Heads radiate, small, with many tubular and four or five ray flowers. A pink variety is not rare, and occasionally cultivated.

Yarrow has a bitterish, fragrant odor and a very bitter taste. The former is due to an *essential oil* of composite character, and of different physical properties, according as it is distilled from the flowers, herb, or root. The ordinary oil (from both flowers and leaves) is of a dull, greenish-blue color, pungent aromatic odor, and burning camphoraceous taste. The yield is very small. Its bitterness is due to a dark-red uncrystallizable substance called *achillein*, also present in other species of *achilleæ*. It is a doubtful alkaloid, and may also be decomposed into glucose and *achilletin* by the usual treatment with acid.

Yarrow, like thoroughwort, is an aromatic bitter tonic, with far more emphasis upon the bitter than aromatic properties. It has been given, like most of its class, in intermittent fever, with reputed benefit, and it still is given for amenorrhœa, etc., occasionally as a popular remedy. It has no special value in any of the above directions.

Dose rather indefinite, best given in infusion.

Allied Plants, etc.—Thoroughwort, Chamomile, etc. *Santolina chamæcyparissus*, by some botanists included in the same genus with yarrow, is the *santoline* or *aurone femelle* of the Codex.

W. P. Bolles.

YAWNING. Synonyms: Gaping, Oscitation; Germ., Gähnen; Fr., Bâillement.

Definition.—Yawning is a physiological modification of respiration by which the act is intensified. It consists in an involuntary, forcible, and profound inspiration, followed by a pause and a prolonged expiration. When fully developed, it is accompanied by a wide opening of the mouth, an elevation of the velum palati, and depression of the larynx, a roaring sound, and usually a click in each ear, a flow of saliva, and a suffusion of the eyes with tears, and a more or less imperative impulse to extend the limbs, especially the arms (pandiculation), to bow and twist the trunk, and to throw back the head. The inspiratory act is frequently audible, and the expiration usually acquires a distinct blowing sound. The elevation of the palate closes the posterior nares and causes the air to be admitted wholly through the mouth. In the same way the Eustachian tubes are closed, causing momentary obtunding of hearing. The contraction of the palatal muscles often precedes the opening of the mouth, and tends to persist for a moment after its closure. The commencement of their contraction is not infrequently accompanied by a rapid succession of three or four short, broken inspiratory efforts.

Physiology.—Yawning is a physiological expression of fatigue and a disposition to sleep. It may, however, arise from a retardation of the respiration, or from any influence which will impair the oxygenation of the blood. It is frequently, therefore, a product of melancholy, languor, ennui, torpor, or debility, or of the malaise which precedes the onset of disease. It is liable to follow prolonged abstraction of mind or concentration of thought. It is sometimes the result of feeble or laborious digestion, of gastralgia, or of other disorder of the digestive organs; or it may occur in response to a demand for increased activity of circulation. It may be sympathetic. To some individuals it is habitual, occurring without fatigue, and being but the outgrowth of the lassitude or indolence of their natures. It may sometimes be attributed to the possession of an inferior degree of intelligence, a slothful, inactive, effeminate, timid, or lustful disposition, incapable alike of vigorous mental exertion or of prolonged physical activity.

That yawning may be the response to a demand for increased activity of oxygenation in the lungs, is demonstrated by placing an animal in an irrespirable atmosphere. Repeated yawning occurs shortly before the animal succumbs to asphyxia. The phenomenon is therefore usually explained on the supposition that it is due to a stimulus transmitted from the central nervous system in response to a peripheral impression, in most cases arising, in part at least, from the respiratory apparatus. Longet has attributed it to the accumulation of too great a quantity of venous blood in the right side of the heart, whence the peripheral impression is supposed to proceed. From whatever source we derive the peripheral impression, however, the act is generally admitted to be reflex in character. Of the reflex nature of the stimulus which produces the muscle-contractions in the extremities, there can be no doubt; for it is a matter of repeated observation that the hand which, owing to paralysis, has been for years beyond control of the will, and has become firmly contracted by post-paralytic rigidity of its flexor muscles, will often become distended during yawning. It is evident here that the stimulus can emanate only from the spinal centres.

The mechanism of yawning is the same as that of normal respiration; the same muscles are called into action, but their movements are more extended. (See Respiration, Vol. VI., p. 205.) The diaphragm, the scaleni, the sterno-cleido-mastoids, the clavicular portions of the trapesii, the lesser pectorals, the subclaviculars, the external intercostals, the serrati magni, the rhomboids—in fact, all the muscles which normally act as direct or as auxiliary forces in the full expansion of the chest, take part in the inspiratory movement. And all the muscles of forced expiration are called into action in the expiratory stage. In the fully developed yawn there is the action also of the muscles of the face, the depressors of the lower jaw, the dilators of the nostrils and upper lip, the orbiculares palpebrarum, the zygomatics, and of the depressors of the hyoid bone and larynx, and finally of the muscles of the back in the bowing of the trunk, and of the extensors of the extremities when stretching occurs.

Yawning is involuntary. It begins without the sanction of the will, and, once begun, it cannot be arrested. In this it resembles sighing, sneezing, hiccough, and other modifications of respiration, without, however, possessing their full spasmodic quality. Yet the will is not entirely deprived of influence over it; for a yawn may be often in a measure concealed by a forcible effort at closure of the jaws, and the mouth may be closed before the yawn has subsided. It may be imitated, but no amount of effort will induce it unless a sufficient cause for it exist. As Carpenter says, "this act may be performed by the will, though not completely; and is one that is particularly excited by an involuntary tendency to imitation, as everyone must have experienced who has ever been in company with a set of yawners."

After yawning there is usually a momentary pause in the respiratory movements, followed by normal, tranquil breathing. The forced respiration has not only supplied the blood with its needed oxygen, but, aided by the muscular contractions, has removed venous engorgement and accelerated the systemic circulation. At the same time, a moment's relaxation has been given to the fatigued body, and a sense of relief is usually afforded.

Symptomatology.—The value of yawning as a symptom has been at different times very differently estimated. Hippocrates recognized it as a precursor of a fever, particularly of intermittent fever. From its frequency and intensity, he prognosticated the severity and duration of the disease. Yawning, with suffusion of the eyes and [illegible], was actually found present [illegible] known in the diagnosis of the [illegible] type. Occurring during menstruation, it was as well known. [illegible] in 1756, believed that he had observed a death from it. The yawning of the animal was also a cause for [illegible].

It is now comparatively seldom, however, that we think of yawning as being an indication of [illegible], [illegible] a diseased state of the system. But this is not denied, a diseased state of the system, it is a well-recognized fact. As indicative of fatigue it may be a symptom of profound mental or physical exhaustion. It may, in fact, if it is persistent, constitute a morbid condition of spasmodic nature and of grave import. It is not infrequently indicative of a deficient oxygenation of the blood, especially when it is associated with the dyspnœa which results from the lung accumulations in cases of pneumonia, the lung complications of hydrothorax or pneumothorax, or after profuse and exhausting hemorrhages. In the latter connection, it is at times a valuable factor in the diagnosis of concealed hemorrhage.

Modern experience has but confirmed the observations of the ancients with regard to the occurrence of yawning in the prodromal stage of fevers, particularly of the intermittents. In these, as also in such morbid affections as epilepsy, hysteria, catalepsy, and [illegible], frequent yawning often signifies the immediate supervention of a seizure. When it occurs during the course of a disease it not seldom indicates the approach of resolution or of a crisis. It is so frequently observed during parturition, however, as a consequence merely of fatigue, that no great significance is now attached to it.

As a symptom of hysteria in suppressed menstruation in young girls it is probably in most instances a manifestation of hysteria, or at least a complication of this disorder. It is probable also that many of the reported cases of spasmodic yawning have been of hysterical origin. Nevertheless, cases have been reported in which yawning of a spasmodic character developed without hysteria, and [illegible] spasmodic [illegible], crying, sneezing, etc. Of a more [illegible], the affection may be indicative of various disorders of the central nervous system, particularly of cerebral anæmia, of circulatory disturbances in the medulla oblongata, or it may occur in the wake of cerebral hæmorrhage. It also shows a predilection for individuals who, from necessity, are confined in small, closely crowded work rooms, and for convalescents from paralytic affections, especially paralysis and [illegible].

In the surgical yawning is of interest chiefly on account of its occasionally producing luxation of the lower jaw. The mechanism of this accident is considered under Dislocations, Vol. II., p. 486. *James M. French.*

YEAST (*Cerevisiæ Fermentum*, Br. Ph.; also Leaven, Yeast cake or powder, and the now almost universally used term, "Compressed," or German Yeast).

The well-known alcohol ferment. It consists essentially of living minute Saccharomyces (Torula) Cerevisiæ Meyen, Order, Saccharomycetes, mixed or diluted, according to circumstances, with starch, sugar, malt, meal, or even other farinaceous or saccharine substances, and sometimes with hops.

This little plant consists in its usual form of single ovoid cells, containing turbid protoplasm and vacuoles (see Fig. 4881), about the $\frac{1}{3000}$ of an inch in length. These cells, in active state, increase in numbers to an almost limitless extent by budding (Fig. 4881, ii, iii, iv), usually separating sooner or later as the new cells attain any considerable size, but also often, especially upon the surface or where the fermentation is closed, cohering into a chain or colonies. In, under rare circumstances, certain cells are [illegible] formed in which two or several cells are [illegible], and finally liberated by the disappearance of the original cell wall. These then grow and bud in the usual way as the parent. During the growth and multiplication of these little cells sugar and the albuminous matters are [illegible] decomposed into alcohol and carbon dioxide (see FERMENTATION, Vol. III.).

The early history of yeast is lost in antiquity. It is frequently mentioned in the Bible as leaven, and in some shape or another has been and is used by nearly all races of mankind. Its production in the great beer and spirit breweries of Europe and America amounts to thousands of tons, and it is consumed and often made in nearly every family of Christendom.

As a commercial product, yeast exists in three principal forms: 1. Brewer's Yeast (official in England), the sediment of the fermenting beer-vats, containing the plant in a state of high activity, of which the following is the official description: "Viscid, semi-fluid, frothy, exhibiting, under the microscope, numerous isolated, rounded or oval cells, or short-branched filaments composed of united cells; odor peculiar; taste bitter." 2. Cake yeast (dry), consisting of the above mixed with starch, flour, or, in this country, Indian meal, rolled and cut into little blocks and dried; and finally, 3, superseding both the above forms for domestic use in cities and towns, the German or Compressed Yeast in little moist cakes enclosed in tinfoil, which consists of an almost solid mass of yeast cells with a minimum of starch or sugar. This is made by taking the beer skimmings and repeatedly washing and straining them, and allowing the cells to settle, and finally pressing nearly dry between cloths; or by propagating them in a [illegible] mixture of barley-malt, rye-flour, and barley, and collecting, washing, and pressing in the same way. "Compressed" Yeast is a very concentrated and active form of Yeast. In its moist state, however, it does not keep very well, and should be obtained fresh every day or two, and laid in the coolest place until wanted.

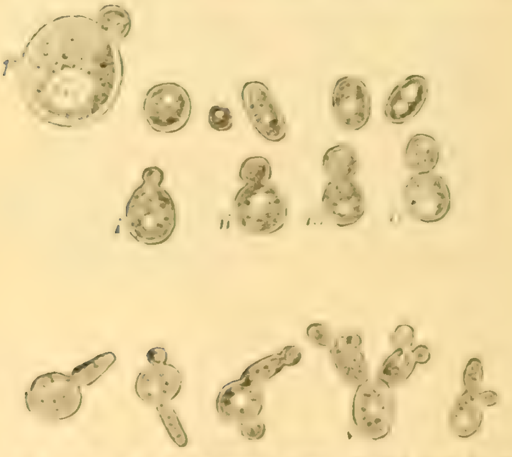

FIG. 4881.—Cells of Ordinary Brewers' Yeast. (Copied from [illegible]) [illegible]

Into the general uses of yeast it is not the design of this article to enter. It is concerned in the production of all beers, wines, and liquors, and of the common "raised" breads and cakes. As a [illegible] of food in these latter, it has considerable hygienic importance, which, mixed with a moderately thick dough, the development of carbonic acid taking place throughout fills it with innumerable minute vesicular bubbles, or makes it "spongy," as the housewives say, or "light." If baked in this condition these bubbles expand with the heat, making the bread still "lighter," or more porous, and in a condition for more ready disintegration in the stomach and intestine than breads made without yeast, and depending upon the evaporation of water only for their lightness. The alcohol is mostly dissipated in the baking and cooling of the bread; the cooked yeast itself is probably of no special dietetic consequence.

In medicine Yeast is now scarcely used. It has been given in indigestion, dyspepsia, etc., but is of little consequence (there are yeast-cells in or upon our food almost always). Dose of liquid yeast, fifteen or twenty grams (℥ ss.). It still survives to a moderate extent as a poultice (*Cataplasma Fermenti*, Br. Ph.), which is simply a thin raised dough.

"Take of

Beer yeast...........................	6 fluid ounces.
Wheaten flour......................	14 ounces.
Water heated to 100 F. (37.8 C.)....	6 fluid ounces.

Mix the yeast with the water and stir in the flour. Place the mass near the fire till it rises" (Br. Ph.).

Yeast poultice is a light, agreeable application, and is thought to overcome the odor and reduce the decomposition of sloughing sores. It is seldom used in this country.

ALLIED PLANTS.—The species of *Saccharomyces* and related ferment-forms are as great a puzzle to botanists as their actions are to chemists, but so much is certain that there are several distinct forms, each of which is capable of producing a specific change in a number of substances; their forms are not always easily distinguishable. The lactic, butyric, and acetic acid fermentations, and others, have each been shown to have peculiar cell-growths accompanying them which can be propagated and isolated like Yeast, for the purpose of producing them. See FERMENTATION. *W. P. Bolles.*

YELLOW FEVER. *Definition.*—A specific infectious disease, contracted by exposure in infected localities; characterized by a single febrile paroxysm of short duration (two to five days , by the presence of albumen in the urine, an icteric color of the skin, and a tendency to passive hæmorrhages from mucous surfaces—especially from the stomach—producing "black vomit."

History and Geographical Distribution.—The geographical range of yellow fever is more restricted than that of any other acute infectious disease, and within the area of its prevalence it is essentially a disease of the littoral, and especially of seaport cities. While occasional epidemics have occurred upon the southwest coast of the Iberian peninsula, the disease, as an epidemic, is unknown elsewhere in Europe, and there is no evidence that it has ever invaded the great and populous continent of Asia. In Africa it is limited to the west coast. In North America, although it has occasionally prevailed as an epidemic in every one of our seaport cities as far north as Boston, and in the Mississippi Valley as far north as St. Louis, it has never established itself as an endemic disease within the limits of the United States. Vera Cruz, and probably other points on the Gulf coast of Mexico, are however at the present time, endemic foci of the disease. In South America it has prevailed as an epidemic at all of the sea-ports on the Gulf and Atlantic coasts, as far south as Montevideo and Buenos Ayres, and on the Pacific along the coast of Peru.

The region in which the disease has had the greatest and most frequent prevalence is bounded by the shores of the Gulf of Mexico, and includes the West India islands. Within the past few years yellow fever has been carried to the west coast of North America, and has prevailed as an epidemic as far north as the Mexican port of Guaymas, on the Gulf of California.

The idea that yellow fever may originate *de novo*, within the area of its occasional prevalence, was entertained by many medical authors during the first half of the present century, and is still held by a few. Thus Cornillac (1886) says: "In the zone which is habitual to it, yellow fever may develop at a given moment without apparent cause. It is born spontaneously at a point of this zone, or at several at a time, and neither the temperature, moisture, barometric pressure, electricity, or finally effluvia given off from the soil, can explain this sudden invasion." It is true that, in localities where the disease is endemic, cases occur which are not directly traceable to importation, but it is also true that in the principal endemic foci of the disease, such as Vera Cruz, Havana, and Rio Janeiro, yellow fever was at one time unknown, and we have reliable historical data fixing the date of its importation. In short, a careful consideration of the historical evidence relating to the disease gives no support to the idea of independent local origin, any more than in the case of small-pox, cholera, or other specific infectious diseases.

But the early history of the disease is involved in obscurity, and we are at present unable to determine whether, as maintained by some, it was endemic at certain points on the shores of the Gulf of Mexico at the time of the discovery of the "new world," or whether it was imported to the West Indies from the African coast, as maintained by others. The early historians, Herréra, Oviédo, Rochefort, and others, make reference to epidemics among the natives which occurred prior to the discovery of the Antilles, and to fatal pestilential diseases among the first settlers of these islands; but their accounts are not sufficiently exact to enable us to affirm that the disease referred to by them was yellow fever. The west coast of Africa was discovered and colonized to some extent before the discovery of America, but the first authentic accounts of the prevalence of yellow fever on this coast date back only to the year 1778, over two centuries after the first settlements had been established. On the other hand, this very epidemic of 1778 at St. Louis (Senegal), was traced to importation from Sierra Leone, a portion of the African coast which, according to Hirsch, "appears to be the head-quarters of the disease, and the starting-point of its epidemic inroad into the territories lying to the north and south, as well as into the West African islands."

Rochefort, whose "Histoire naturelle et morale des isles Antilles de l'Amérique" was published in Holland in 1558, says of the West Indies: "The air of all those islands is very temperate, and healthy when one is accustomed to it. The *peste* was formerly unknown there as well as in China and other places in the Orient; but some years since the islands were afflicted with malignant fevers, which the physicians considered contagious. The bad air was brought there by some ships which came from the coast of Africa, but at present we hear nothing more of these maladies."

It seems very probable that a pestilential malady which prevailed for a time in these usually healthy islands and then disappeared, was in fact yellow fever, and that it was introduced by ships from the west coast of Africa is not at all incredible. Indeed, it almost seems necessary to look for an original endemic focus of the disease outside of the West Indies, for the reason that, in the comparatively few places where it is now endemic, there is historical evidence to show that there was a first importation and a previous period of exemption; while, on the other hand, the conditions upon which endemicity at the present day seems mainly to depend, were formerly unknown—conditions arising from the aggregation of population at seaport cities, as at Havana, Vera Cruz, and Rio Janeiro.

Some authors have attempted to identify the epidemic disease mentioned by Humboldt—called by the natives "Matlazahuatl"—which prevailed in Mexico in 1545, 1576, 1736–37, and 1761–62, with yellow fever; but, as pointed out by Hirsch, this disease prevailed almost exclusively among the natives of the interior and of the table-land of Mexico, while yellow fever is essentially a disease of the littoral.

Cornillac, a recent French author who has made a careful study of the sanitary history of the West Indies, as contained in the works of Oviédo, Herréra, Gomara, and other Spanish authors of the sixteenth century, arrives at the conclusion that the pestilential disease from which the settlers in the first Spanish colony at Nueva Isabella, and at Santo Domingo (1494–1514), are said to have suffered, and which was characterized by a "saffron-yellow" color of the skin, was in truth yellow fever. While it appears quite probable that this was so, we cannot accept it as demonstrated, as the first authentic accounts of yellow fever in the West Indies date from about the middle of the following century.

In 1635 a French colony was established upon the island of Guadeloupe, and shortly after their arrival a pestilential disease appeared among the colonists which, from the account given by Dutertre, a Catholic priest who resided in the island five years (1640–47), is accepted by Hirsch and by Cornilliac as having been yellow fever. From Dutertre's account, however, as quoted by Cornilliac, it would appear that yellow fever was first imported into the island of Guadeloupe in the year 1648, and that the great mortality previously reported was due to other causes. Dutertre says: "During this same year 1648 the [illegible] which was unknown in these islands since they were inhabited by the French, was brought there by a ship. It commenced at Saint Christophe, and during the eighteen months that it lasted carried away nearly one-third of the inhabitants. The epidemic [illegible] in those who were attacked a violent pain in the head, great [illegible] in all the members, and continual vomiting, so that in three days it put a man in his tomb. This [illegible] certainly was brought to Guadeloupe by a ship from La Rochelle, called Le Bœuf."

At Barbadoes the disease may have prevailed for some years prior to its introduction to Guadeloupe, but the first authentic account relates to the year 1647. Richard Ligon, who arrived at the island in the month of September of that year, says that the city of Barbadoes was at that time suffering from a scourge which caused great ravages, so that the living scarcely sufficed to bury the dead. According to this author, the cause of this epidemic was unknown; it was uncertain whether it had been imported, or whether it originated from bad food, the use of impure water, and the intemperance of the colonists. Ligon inclines to attribute it largely to the latter cause, and remarks that not more than one [illegible]. We may safely assume, from the subsequent history of the island of Barbadoes, that the malignant plague referred to by Ligon was not of local origin, but with a rapidly increasing population this island has enjoyed considerable periods of immunity from yellow fever, and when epidemics have occurred they have, as a rule, been clearly traced to importation. From this time—1647–48—the history of yellow fever in the West Indies is a history of epidemic outbreaks at varying intervals, at the principal seaport towns, traced sometimes to importation, but more commonly assumed to be of local origin. It was epidemic in Jamaica in 1655, and again in 1671; at Santo Domingo in 1656; at Martinique in 1686 and 1690. In 1699 it prevailed widely as an epidemic in the West Indies, and, according to Hinemann, made its first appearance at Vera Cruz, the principal seaport on the Gulf coast of Mexico.

Cuba.—I cannot attempt to follow here the history of yellow fever in the West Indies generally, but shall give an account of its prevalence in Havana, as this is now the endemic focus of the disease and the point which is the most dangerous to the United States, on account of its proximity and the constant commercial intercourse between this city and our own seaports.

The historian Pezuela records the prevalence of a malignant pestilential disease in Havana in 1648, a year in which, as we have seen, yellow fever was epidemic in the islands of Guadeloupe and of Barbadoes. He says: "In this year there occurred in Havana a great and [illegible] pestilential fever which prevailed in the port almost all the summer. A large part of the garrison and a larger part of the crew and passengers in the vessels died." The epidemic continued the following year, and in 1653–54, according to the author above quoted, "the epidemic was renewed with equal fury," and in 1655 "in the capital continued to carry away its victims without regard to condition and position." According to Dr. S. E. Chaillé, President of the Havana Yellow Fever Commission (1879), from whose report we have quoted the above extracts from Pezuela, there is no historical evidence of the prevalence of yellow fever in Havana for more than a hundred years after the date mentioned. On the contrary, there are repeated records of the great salubrity of the climate and the absence of epidemic disease.

It was not until the year 1761 that yellow fever established itself in the previously healthy city. Pezuela gives the following account of its introduction: "Although Havana is situated on the northern boundary of the torrid zone, it was very justly considered one of the most healthy localities on the island before its invasion, in a permanent manner, by the vomito negro, imported from Vera Cruz in the summer of 1761. . . . . In May there came from Vera Cruz, with materials and some prisoners destined for the works on the exterior fortifications of Havana, the men-of-war Reina and América, which communicated to the neighborhood the epidemic known by the name of 'vomito negro.' At the end of the following June there were stationed in this port nine men-of-war, despatched from Cadiz, and sent to the chief of the squadron, Don Gutierre de Hevia; they brought a reinforcement of 2,000 men. More than 3,000 persons succumbed to the epidemic on this *the first appearance* of the vomito."

From this time to the present day the new levies of troops sent from Spain to Cuba have continued to suffer enormous losses from the endemic pestilence. In 1779 there arrived from Spain, then at war with Great Britain, "an army of 8,000 men, which was immediately decimated by the vomito." In 1780 during the month of August, an army of 8,000 men was landed in Havana, which during the two following months suffered a loss of about 2,000 men with the vomito. Pezuela records the fact that in 1794, in the garrison and squadron, there were more than 1,600 victims to the disease.

The endemicity of yellow fever in Havana was fully established by the researches of the commission sent to that city in 1879, by the National Board of Health. Dr. Chaillé, president of this commission, says in his preliminary report, published in 1881: "Since 1761 yellow fever has prevailed certainly in Havana, and probably in other places in Cuba, every year, and the dates of prevalence recorded in our text-books indicate no more than the years of greatest prevalence. The disease prevails in Havana, and in some other places in Cuba, not only every year, but also every month in the year; records in 1857 indicate that at that date the monthly prevalence had become habitual in Havana; the statistics, solely of the military and civil hospitals, prove that during the 108 months, 1870–79, there was only one single month free from an officially recorded case of yellow fever."

The following tables are from the "Preliminary Report of the Havana Yellow Fever Commission:"

Monthly Maximum and Minimum Deaths by Yellow Fever in Havana during the Ten Years 1870–79.

Month.	Minimum.	Maximum.	Month.	Minimum.	Maximum.
January	[illegible]	[illegible]	July	68	[illegible]
February	4	29	August	7	[illegible]
March	[illegible]	[illegible]	September	46	[illegible]
April	4	[illegible]	October	27	[illegible]
May	11	[illegible]	November	[illegible]	[illegible]
June	66	[illegible]	December	[illegible]	[illegible]

In no one of the ten years 1870–79 has there ever been fewer deaths than in the first, nor more than in the second column, and the total deaths by yellow fever for each year were as follows:

Total Deaths by Yellow Fever in Havana.

In 1870	[illegible]	In 1875	[illegible]
In 1871	991	In 1876	[illegible]
In 1872	[illegible]	In 1877	[illegible]
In 1873	1,244	In 1878	1,559
In 1874	[illegible]	In 1879 (to December 1)	[illegible]

Matanzas has the reputation of having long suffered seriously with yellow fever; the earliest positive date secured by me was reported by Dr. Gutierrez, a member of the Commission, a native of Matanzas, who was assured by one of the oldest physicians that the city suffered with the disease in 1828, when he came to Matanzas, and had prevailed every year since." (Chaillé, op. cit.)

Cienfuegos.—"Yellow fever every year since 1850, except in 1862 and 1874."

Santiago de Cuba.—"Yellow fever prevailed every year, and nearly every month, from 1850 to the present time."

Manzanillo.—"Yellow fever every year since 1866."

Vera Cruz, the principal seaport on the Gulf coast of Mexico, is also the principal endemic focus of yellow fever upon this coast. According to Hinemann, the first epidemic occurred in 1699, a year in which yellow fever was widely prevalent in the West Indies, and in which it prevailed for the first time as an epidemic in the city of Philadelphia.

The following table, which I copy from a paper by Dr. Zacarias R. Molina, a medical officer of the Mexican Army who has for a number of years been on duty in the Military Hospital at Vera Cruz, shows the continued prevalence of the disease in that city during a period of nearly fifteen years:

Mortality from Yellow Fever in the City of Vera Cruz from July, 1867, to December, 1881.

Months.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January	..	7	..	..	3	2	1	1	7	..	..	16	6	2	28
February	..	6	..	..	...	2	..	2	2	1	1	5	4	..	22
March	..	7	..	..	1	4	..	..	4	1		..	2	1	29
April	..	31	2	..	6	5	3	..	11	..	..	1	1	1	29
May	..	42	..	..	19	14	1	2	29	..	4	7	1	..	94
June	..	16	..	..	113	45	19	3	93	2	7	58	1	..	233
July	8	28	1	..	71	53	59	11	118	4	54	114	2	1	132
August	29	21	1	..	17	39	59	24	105	7	144	110	1	3	39
September	36	21	..	..	10	29	74	7	41	9	164	62	3	9	22
October	17	9	1	3	15	11	20	12	13	6	77	45		42	25
November	11	2	2	5	2	..	10	11	2	1	50	24	..	92	18
December	8	3	..	2	4	6	7	6	..	3	27	7	..	98	4
Totals	109	193	7	10	271	210	223	79	425	31	528	444	21	249	675

There is no evidence of continued prevalence at other towns upon the Mexican coast, but epidemics, which have usually been traced to importation from Vera Cruz, have occurred at *Matamoras* (1858, 1863, 1867); at *Tampico* (1821, 1836, 1845, 1847, 1853, 1864); at *Tuxpan* (1863, 1875, 1877); at *Campeché* (1865, 1877), and at *Manzanillo* (1868).

The Gulf coast of South America, and especially the English and French settlements in Guiana, have been frequently visited by epidemics of yellow fever, and it is probable that the disease is endemic at one or more points upon this coast. Its epidemic prevalence is recorded for the following years at *Demerara:* 1793–96, 1800, 1803, 1818, 1819, 1820, 1821, 1825, 1827, 1828, 1831, 1837–39, 1841–45, 1851–53, 1861–66 (Hirsch).

In Venezuela the disease has prevailed at the capital, *Caracas*, and the neighboring seaport, *La Guayra*, in the years 1693, 1696, 1793, 1797, 1802, and 1869.

In Central America epidemics have occurred at all of the principal seaports: *Panama*, 1740, 1858, 1859, 1867. *Portobello*, 1726, 1729, 1740, 1793, 1860, 1866, 1867; *Belize*, 1860; *Nicaragua*, 1868.

Brazil.—The Portuguese author El hastião da Rocha Pitti has given an account, in his "History of Portuguese America," published in Lisbon in the year 1730, of an epidemic malady which prevailed in Pernambuco in the year 1686, which very probably was yellow fever. This author says (Book VII., p. 427 et seq.): "In the year 1686, commenced in Pernambuco that terrible plague (contagious disease, *Bicha*) which must be attributed to the sins of the population of these provinces, corrupted by the vices into which they were enticed by the wealth and freedom of Brazil. Many causes are alleged, the most worthy of attention being the arrival of some barrels of meat which returned from the island of São Thomé (St. Thomas). These were opened by a cooper, who shortly afterward fell dead. Soon after several persons of his family, to whom he had communicated the disease, also died. The epidemic spread to such an extent among the inhabitants of Recipe (Pernambuco) that the mortality exceeded 2,000, which was very large in proportion to the population. Thence the disease extended to Olinda and its vicinity, and very few were the persons who escaped it, such were its virulence and intensity."

The account given by the historian of the clinical features of this pestilential disease is, of course, very imperfect, but it seems to justify the belief that the disease was really yellow fever.

The highest medical authorities in Brazil agree that yellow fever was not endemic in the principal seaports of the empire prior to the year 1849, when it was introduced to the city of Bahia by the North American brig Brazil, which sailed from New Orleans, where yellow fever was prevailing, and touched at Havana. Two of the crew of this brig died of yellow fever during her voyage from the latter port to Bahia. Soon after her arrival the disease made its appearance among those who had communicated with the ship, and later, on other vessels in the harbor. The first case occurred a few days after the arrival of this brig (November 3d). A part of her cargo is said to have consisted of little barrels of beef which had become putrid. From Bahia the disease was carried to Rio Janeiro, where during the epidemic season of 1850 it caused a mortality of 4,160.

According to Professor Barata, of the Faculty of Medicine of Rio Janeiro, yellow fever continued to prevail in Brazil until the year 1861, when it disappeared for eight years, to reappear in 1869–70, as the result of a fresh importation. The Italian ship Creolla del Plata, which had touched at St. Iago, where yellow fever was prevailing, is named as the vessel which introduced the disease on this occasion.

The mortality from the disease under consideration in the city of Rio, from the time of its introduction in 1850 to a recent date, is shown by the following table:

	Mortality.		Mortality.
1850	4,160	1869	274
1851	475	1870	1.117
1852	1,943	1871	8
1853	853	1872	102
1854	21	1873	3 659
1855	0	1874	829
1856	0	1875	1.292
1857	1,425	1876	3,317
1858	800	1877	282
1859	500	1878	1.174
1860	1,249	1879	974
1861	247	1880	1 433
1862	12	1881	219
1863	0	1882	95
1864	0	1883	1.336
1865	0	1884	618
1866	0	1885	278
1867	0	1886	1 397
1868	0		

In 1855 yellow fever is said, by Hirsch, to have prevailed extensively in Brazil, although this was not an epidemic year in Rio Janeiro. The following year it extended along the Amazon far into the interior of the country. The years of greatest epidemic prevalence since that date have been 1859–60, 1862, 1869–70, 1872–73, 1875–77 (Hirsch).

From Brazilian ports the disease has occasionally been introduced to the cities at the mouth of the Rio de la Plata, and has there caused great loss of life. The first epidemic at *Montevideo* was in 1857, and it was again introduced into this city, from Pernambuco, in 1872. It prevailed in the city of *Buenos Ayres* in 1858 and in 1870.

Yellow fever is said to have been conveyed to the Pacific coast of South America by a party of German emigrants, who landed at Callao, *Peru*, in 1854. The disease spread from this port to the capital, and in the course of the next two or three years to the principal towns upon the Peruvian coast, where it continued to prevail up to the year 1869.

Chili, up to the present time, has remained exempt from the disease (Hirsch).

Upon the *West Coast of Africa* the head-quarters of yellow fever is that portion of the coast which belongs to the province of *Sierra Leone*, and epidemics at other points upon the African coast have frequently been traced to this locality. It seems very doubtful, however, whether, as some authors suppose, this is really the original source of the disease. The French authors Bérenger Feraud and Bourru both call attention to the fact that we have no account of the disease prior to the year 1775, although the African coast was discovered and colonized long before the discovery of the West Indies, and that, on the other hand, the early settlers in these islands suffered from a pestilential malady which very probably was yellow fever.

At St. Louis (Senegal) an epidemic occurred in 1778, and this is the first outbreak of the disease of which we have any reliable information in this portion of the world. The disease in this instance is said by Schotte to have been imported from Sierra Leone, where epidemics are recorded to have occurred during the present century in 1823, 1829, 1837, 1838–39, 1847–59, 1845–47, 1859, 1862, 1864, 1865–66, 1866, 1878 (Hirsch). Frequent epidemics have also occurred at Senegambia, and the disease has prevailed upon the Gold Coast (1852, 1857, 1862), the Loango Coast (1816, 1861, 1862, 1865), at the Cape Verd Islands (1845, 1862, 1868), and the Canary Islands (1701, 1771, 1810, 1846, 1862).

In Europe the ravages of yellow fever have been restricted mainly to the Iberian peninsula. This is due, no doubt, to the frequent intercourse between Spain and Portugal and the West Indian ports, in which the disease is most prevalent, and to the fact that the summer temperature of these countries is favorable for the epidemic extension of the disease; whereas the more northern portions of Europe are practically outside of the yellow-fever zone.

The first epidemic in Spain occurred in the year 1700, at Cadiz. This city also suffered in 1730–31, 1733–34, 1764, 1780, 1800, 1804, 1810, 1819–21. The epidemics of 1800, 1810, and 1819 were not limited to the city of Cadiz, but the disease extended to the interior and caused a considerable loss of life in the provinces of Granada and Andalusia, and also in some of the towns of Murcia and Catalonia—especially in Barcelona, from which city the disease was conveyed to the island of Majorca during the last epidemic. No subsequent epidemic has occurred in Spain since 1821, but local outbreaks, as a result of importations from the West Indies, have occurred in Gibraltar (1828), Barcelona (1870), and Madrid (1878).

The first epidemic at Lisbon was in 1723; a second was inaugurated in 1856, and during the following year developed into a devastating scourge which extended to the towns of Belem, Olivaes, and Almada.

In *Italy* yellow fever has only once effected a temporary lodgment—at Leghorn, in 1804, where it was imported from Spain.

Ships with yellow fever on board have occasionally arrived at English and French ports, but local conditions have apparently not been favorable to an extension of the disease, except to a limited extent at Brest in 1856, at St. Nazaire in 1861, and at Swansea (Wales) in 1864.

Bahama Islands.—Yellow fever prevailed as an epidemic at Nassau in 1861, 1862, 1864, and in 1869.

According to Hirsch, yellow fever prevailed to a limited extent at Halifax (latitude 44° 20') in 1861, and at Quebec (latitude 46° 50'), in 1805.

PREVALENCE OF YELLOW FEVER IN THE UNITED STATES. *New Hampshire.*—Portsmouth is the most northern point in the United States which has suffered an epidemic of yellow fever. In 1798 and again in 1802, during which year the disease was epidemic in New York and in Philadelphia, it was also epidemic in this city.

Massachusetts.—In 1693 an English expedition sailed from Boston for the purpose of taking from the French the island of Martinique. The expedition failed in its object and returned to Boston on June 11th, with yellow fever on board the vessels of the fleet. Hutchinson, in his "History of Massachusetts Bay," says the mortality among the sailors had been 1,300, out of a total strength of 2,100, and that out of the same number of soldiers the loss was 1,800. He states that the disease spread from the fleet to the town, and that many families left town and resided in the country until the infection had ceased. This is the first authentic account of the occurrence of yellow fever within the present limits of the United States. In 1796 the disease prevailed to a limited extent in Boston and in Newburyport. In 1798 it prevailed as an epidemic in Boston, where the mortality was 200, and in 1802 66 fatal cases occurred in the same city. Some cases also occurred in the years 1800, 1819, and 1858.

Rhode Island.—The city of Providence was several times visited by yellow fever during the latter part of the eighteenth and the beginning of the present century—1794, 1796 (mortality 45), 1797 (mortality 45), 1800, 1805. The disease prevailed at Newport in 1798, and at Bristol in 1797.

Connecticut.—The disease prevailed at New London in 1795, and again in 1798, when the mortality was 81. Hirsch records the occurrence of the disease at New Haven in 1743, 1794, and 1805; at Middletown in 1820; at Chatham in 1796, and at Hartford in 1799.

New York.—Epidemics of greater or less extent have occurred in New York City and its immediate vicinity in 1668, 1702, 1743 (mortality 217), 1745, 1762, 1791, 1794, 1795 (mortality 730), 1798 (mortality 2,086), 1799 (mortality 76), 1800, 1801, 1803 (mortality 700), 1805 (mortality 400), 1809, 1819, 1822 (mortality 230), 1848, 1853, 1854, 1856, 1870 (mortality 49).

New Jersey.—Hirsch records the following local epidemics: Bridgetown, 1798; Chews, 1798; Woodbury, 1798; Perth Amboy, 1811.

Pennsylvania.—According to La Roche, "the earliest onset of the disease occurred in 1699, when Philadelphia, then but seventeen years of age, was little more in point of extent than an ordinary country town." There are no medical accounts of this epidemic, but there is no doubt as to the nature of the disease, which caused a mortality of 220 in the new city, estimated to have contained less than four thousand inhabitants. The next epidemic in Philadelphia occurred in 1741, when the mortality was 250. Subsequent epidemics occurred in 1747, 1762, 1793 (mortality 4,041), 1794, 1797 (mortality 1,300), 1798 (mortality 3,500), 1799 (mortality 1,000), 1802 (mortality 307), 1803 (mortality 195), 1805 (mortality 400), 1819, 1820 (mortality 83), 1853 (mortality 128), 1870 (mortality 18).

Delaware.—In the epidemic of 1798 the city of Wilmington suffered a loss of 250.

Maryland.—Epidemics, for the most part of limited extent, have occurred in Baltimore in the years 1783, 1794, 1797, 1798, 1799, 1800, 1802, 1819, 1820, 1821, 1822, 1868, 1876.

Virginia.—At Norfolk epidemics are recorded as follows: 1737, 1741, 1794, 1795, 1797, 1799, 1800 (mortality 250), 1801, 1821, 1826, 1855 (mortality 1,807). An epidemic occurred at Petersburg in 1798, and at Alexandria in 1803. At Portsmouth the disease prevailed in 1852, 1854, and 1855 (mortality 1,000).

North Carolina.—Wilmington, 1796, 1800, 1821, 1862 (mortality 446); Newbern, 1799, 1864 (mortality 700); Beaufort, 1854, 1864 (mortality 68), 1871; Washington, 1800; Smithville, 1862.

South Carolina.—The first epidemic of which we have any account, at Charleston, occurred in 1693; from this time epidemics have been numerous, and during the first half of the present century the physicians of Charleston generally considered the disease endemic in that city. That it was not seems to be demonstrated by the immunity enjoyed since 1871, an immunity which is probably due to the diminished commerce with infected ports in the West Indies, and to a more efficient quarantine service, since the fact has been recognized that the disease is not endemic.

The prevalence of yellow fever in Charleston during the present century is shown in the following table; recorded epidemics, prior to the year 1800, are as follows: 1693, 1699, 1700, 1703, 1728, 1732, 1734, 1739, 1745, 1748, 1753, 1755, 1761, 1762, 1768, 1770, 1792, 1794, 1795, 1796, 1797, 1798, 1799 (mortality 239). An epidemic occurred among the troops stationed at Hilton Head in 1862; Port Royal, 1877 (mortality 35).

Georgia.—At Savannah epidemics are recorded in the years 1800, 1807, 1808, 1817, 1819, 1820, 1827, 1852, 1853, 1854 (mortality 580), 1858, 1876; at St. Mary's in 1808 (mortality 84), and in 1876; at Augusta in 1839 and 1854; at Bainbridge in 1877; Brunswick, 1876.

Mortality from Yellow Fever in Charleston, S. C., Pensacola, Fla., Mobile, Ala., New Orleans, La., and Galveston, Tex., during the Present Century.

Year.	Charleston.	Pensacola.	Mobile.	New Orleans.	Galveston.	Year.	Charleston.	Pensacola.	Mobile.	New Orleans.	Galveston.
1800	184	....	....	*	....	1841	*	*	*	594	....
1801	....	....	....	*	....	1842	....	*	60	211	....
1802	96	....	....	*	....	1843	1	*	240	487	....
1803	*	....	....	....	....	1844	....	*	*	148	400
1804	148	....	....	*	....	1845	....	*	....	2	....
1805	*	....	....	....	....	1846	....	*	....	160	....
1806	....	....	....	....	....	1847	....	*	76	2,259	200
1807	162	....	....	....	....	1848	....	*	75	850	....
1808	....	....	....	....	....	1849	125	....	50	737	....
1809	....	....	....	*	....	1850	....	....	....	102	....
1810	....	....	....	....	....	1851	....	....	*	16	....
1811	....	*	....	*	....	1852	310	....	....	415	....
1812	*	....	....	*	....	1853	....	*	115	7,970	536
1813	....	....	....	....	....	1854	627	*	*	2,423	404
1814	....	....	....	....	....	1855	....	....	....	2,670	....
1815	....	....	....	....	....	1856	211	....	....	74	....
1816	....	....	....	....	....	1857	13	....	....	199	....
1817	272	....	....	800	....	1858	717	*	*	3,889	344
1818	....	....	....	115	....	1859	....	....	....	....	182
1819	177	....	274	2,190	....	1860	....	....	....	....	....
1820	....	....	....	*	....	1861	....	....	....	....	....
1821	....	....	*	....	....	1862	*	*	....	....	....
1822	2	257	*	239	....	1863	....	*	....	....	....
1823	....	....	....	1	....	1864	*	....	....	....	259
1824	235	....	*	108	....	1865	....	....	....	....	....
1825	2	*	*	49	....	1866	....	....	....	....	*
1826	....	....	....	5	....	1867	....	34	*	3,093	1,150
1827	64	*	*	169	....	1868	....	....	....	....	....
1828	26	....	*	130	....	1869	....	....	....	....	....
1829	....	....	130	215	....	1870	....	....	*	587	....
1830	30	....	....	117	....	1871	213	....	....	55	....
1831	....	....	....	2	....	1872	....	....	....	40	....
1832	....	....	....	18	....	1873	....	61	27	225	....
1833	....	....	....	210	....	1874	....	118	....	....	....
1834	49	*	....	95	....	1875	....	....	....	....	....
1835	25	....	....	284	....	1876	....	....	....	....	....
1836	....	....	....	5	....	1877	....	....	....	....	....
1837	....	....	350	442	....	1878	....	....	90	600	....
1838	351	....	....	17	....	1879	....	....	....	....	....
1839	134	*	650	452	250	1880	....	....	....	....	....
1840	22	....	....	3	....						

* Number of deaths not stated.

Florida.—The principal sea-port, Pensacola, has suffered frequent epidemics of yellow fever. Those occurring during the present century are included in the table given above. Two epidemics are recorded as occurring prior to the year 1800—1764 and 1765. At St. Augustine epidemics occurred in 1807, 1821, 1838, 1839, and 1841; at Key West in 1823, 1829, 1841, 1862, 1867, 1875, 1878, 1887; at Jacksonville in 1857, 1877, and 1888; at Fernandina in 1877 (mortality 498); at Tampa in 1839, 1853, 1871, 1887.

Alabama.—The recorded epidemics in Mobile, prior to the year 1800, were in 1705, 1765, and 1766; subsequent epidemics are included in the table. Montgomery, 1853 (mortality 35), 1854 (mortality 45), 1855 (mortality 30), 1873 (mortality 102); Selma, 1853 (mortality 32); Florence, 1878.

Mississippi.—The town of Biloxi, on the Gulf, has suffered from epidemics as follows: 1702, 1839, 1847, 1853, 1858, 1878, 1884; Pascagoula, 1847, 1853, 1875, 1878; Port Gibson, 1878; Shieldsborough, 1820, 1829, 1839; Port Adams, 1839, 1853; Grand Gulf, 1853; Natchez, on the Mississippi River, 1817, 1819 (mortality 180), 1823 (mortality 312), 1825 (mortality 150), 1827, 1829 (mortality 90), 1837 (mortality 280), 1839 (mortality 235), 1848, 1853, 1855, 1858; Vicksburg, 1839, 1841, 1847, 1853, 1855, 1858, 1871, 1873, 1878 (mortality 872); Jackson, 1853, 1854, 1878 (mortality 86); Holly Springs, 1878 (mortality 309); Greenville, 1878 (mortality 301); Grenada, 1878 (mortality 326); Canton, 1878 (mortality 180). Our record does not include numerous smaller places which suffered during the epidemic of 1878.

Louisiana.—The first recorded epidemic in New Orleans was in the year 1769; other outbreaks prior to the present century were in 1791, 1793, 1794, 1795, 1796, 1797, 1799. The prevalence of the disease in this city subsequent to the year 1800 is given in the table. Baton Rouge, 1817, 1819, 1822, 1827, 1829, 1837, 1843, 1847, 1853, 1858, 1878 (mortality 193); Opelousas, 1837, 1839 1842, 1853; St. Francisville, 1811, 1817, 1819, 1823, 1827, 1829, 1839, 1843, 1846, 1848, 1853; Shreveport, 1853, 1873 (mortality 759); Port Hudson, 1839, 1841, 1843, 1853, 1878; Thibodeaux, 1846, 1853, 1854, 1878; Washington, 1837, 1839, 1852, 1853, 1854, 1867; Morgan City, 1878 (mortality 109). Numerous smaller places during the epidemics of 1873 and of 1878.

Texas.—The epidemics at Galveston are included in our table. Houston, 1839, 1844, 1847, 1848, 1853, 1854, 1858, 1859, 1864, 1867, 1870; Huntsville, 1867 (mortality 130); Hempstead, 1867 (mortality 151); Indianola, 1852, 1853, 1858, 1859, 1862, 1867 (mortality 80); La Grange, 1867 (mortality 200); Matagorda, 1862 (mortality 120); Navazota, 1867 (mortality 154); Rio Grande City, 1867 (mortality 150); Victoria, 1867 (mortality 200); Brenham, 1867 (mortality 120); Calvert, 1867 (mortality 250); Chapel Hill, 1867 (mortality 123); Columbia, 1867 (mortality 132); Brownsville, 1853, 1858, 1862, 1882.

Tennessee.—Memphis, 1828, 1853, 1855, 1867, 1873 (mortality 1,244), 1878 (mortality 5,000), 1879 (mortality 485); Chattanooga, 1878 (mortality 135); Brownsville, 1878 (mortality 212); numerous smaller towns in 1878.

Arkansas.—Columbia, 1853; Fort Smith, 1823; Little Rock, 1873; Napoleon, 1853.

Kentucky.—Bowling Green, 1878; Hickman, 1878 (mortality 153); Louisville, 1878 (mortality 64).

Ohio.—Cincinnati, 1871, 1873, 1878 (mortality 17); Gallipolis, 1796, 1878 (mortality 18).

Illinois.—Cairo, 1873 (mortality 17), 1878 (mortality 51).

Missouri.—St. Louis, 1854, 1855, 1878 (mortality 16); New Design, 1797 (mortality 57).

Great Epidemics in the United States. 1793.—The city of Philadelphia, after enjoying an immunity from yellow fever for thirty-one years, suffered in 1793 a devastating epidemic. This epidemic, no doubt, resulted from importation, although a clear history of its introduction was not made out at the time, and the leading physicians of the city were inclined to attribute it to local origin, as a result of unsanitary conditions in connection with an unusually high temperature. La Roche says: "Dr. Rush and others laid great stress on a quantity of damaged coffee which was exposed, during the latter part of July, in a place (on a wharf and in the adjoining dock) and under circumstances which favored decomposition. Its smell was highly putrid and offensive, insomuch that the inhabitants of the houses in Water and Front Streets, who were near to it, were obliged in the hottest weather to exclude it by shutting the doors and windows. Even persons who only walked along those streets complained of intolerable fetor, which, upon inquiry, was constantly traced to the putrid coffee."

It appears probable that this "putrid coffee" was indeed the nidus in which the deadly exotic germ first developed which gave rise to this fatal epidemic. Whether the coffee was infected at the port of shipment, or whether it was transported in an infected vessel, we cannot now determine; but that the outbreak of yellow fever in Philadelphia was due to the fact that the coffee was imported from a region where yellow fever was prevailing, or in an infected ship, rather than to the fact that it was putrid, cannot be doubted, in view of the subsequent history of yellow-fever epidemics in the United States.

As usual, the early cases were not recognized as yellow fever. Dr. Rush says: "The report of a malignant and fatal fever being in town spread in every direction, but it did not gain universal credit. Some of those physicians who had not seen patients in it denied that any such fever existed, and asserted (though its mortality was not denied) that it was nothing but the common annual remittent of the city. Many of the citizens joined the physicians in endeavoring to discredit the account I had given of this fever, and, for a while, it was treated with ridicule or contempt. Indignation in some instances was exerted against me." History has repeated itself, in this particular, many times in subsequent epidemics. The early cases, even in cities like New Orleans, where the physicians are well acquainted with the disease are frequently called by some other name—"bilious fever," "putrid fever," "remittent fever," etc.—and the physician who first ventures to name the prevailing disease "yellow fever" is treated with ridicule or with indignation.

It was not until the middle of August that a rapid succession of fatal cases convinced the physicians of the city that the dread West India pestilence was again present in Philadelphia.

The presence of the disease was officially recognized on the 22d of August, when the Mayor of the city gave orders for the cleansing of streets and general purification of the city. The disease continued to extend until early in October, when it reached its height. It did not cease entirely until about the 8th of November. During this short season of prevalence it caused an enormous mortality, distributed as follows: "August, 325; September, 1,442; October, 1,975; November, 118" (La Roche).

The population of the city at this time is estimated to have been a little more than 40,000, which gives a mortality of ten per cent. of the total population (total mortality 4,040). As more than 12,000 of the inhabitants fled from the city, the proportion of those who were attacked is very great. La Roche estimates the total number of cases at 11,000.

1797.—The epidemic of this year in the city of Philadelphia was less extended and less fatal. The whole number of deaths is estimated to have been about 1,300. The disease, as usual, commenced in the vicinity of the wharves about the end of July. Unsanitary conditions, described by physicians who were witnesses of the epidemic, furnished the favorable local conditions for the extension of the germ, which, according to a report of the College of Physicians of Philadelphia made in response to a request from the Governor, was imported by two vessels, one from Havana and the other from Port au Prince. In this report the College of Physicians, contrary to the prevailing popular opinion, and that of many prominent physicians, took the ground that the insanitary local conditions were simply secondary or accessory causes, and recommended "a more stringent system of quarantine regulations, as the most effectual means of preventing the recurrence of the disease" (La Roche).

1798.—The epidemic of 1797 was followed the next year by a still greater one, which was not confined to the city of Philadelphia alone. The disease prevailed also in Boston (mortality 200), in Portsmouth, N. H. (mortality 100), in Newport, R. I. (mortality 21), in New London, Conn. (mortality 81), in New York (mortality 2,080), in Wilmington, Del. (mortality 250), and in Charleston, S. C. The mortality in Philadelphia was 3,645, distributed as follows: August, 626; September, 2,004; October, 956; November (from the 1st to the 5th), 59. The mortality, in proportion to the number of cases, in the city of Philadelphia was excessive, being, according to La Roche, about as 1 to 1.27 of those attacked, or nearly eighty per cent. This is accounted for partly by the fact that the better classes of the community left the city as soon as possible after the outbreak of the disease, and the cases which occurred were consequently among the poorer classes who inhabited the worst portions of the city. The prevailing ideas as to the treatment of fevers by depleting measures were doubtless responsible in some degree for the excessive mortality. "The College of Physicians, faithful to the theory so long entertained by it in relation to the origin of the disease, assigned to the epidemic this year, as it had done to those of preceding seasons, a foreign origin" (La Roche).

1802.—An epidemic of smaller proportions prevailed in the year 1802, causing a mortality in Boston of 60, in Philadelphia of 307, in Wilmington of 86, in Charleston of 96. The disease also prevailed extensively in Baltimore, but no record of mortality is given. The prevalence of the disease at the seaports mentioned, especially before the days of railroad communication, is not to be ascribed to an extension from one to the others, or to "an epidemic constitution of the atmosphere," but is doubtless accounted for, for the most part, as a result of independent importation from the usual source of the disease—the West Indies. Thus we find that in 1802, while Boston and Philadelphia suffered epidemics, New York, lying between the two infected points, was free from the disease (two cases only are reported).

1853.—Passing over the minor epidemics, for the most part limited to a single city, or by coincidence [illegible] to two or more distant seaports, we come to the epidemic of 1853, which extended through portions of the States of Florida, Alabama, Louisiana, Mississippi, Arkansas, and Texas. The towns which suffered in *Florida* were Pensacola, Milton, and Tampa. In *Alabama* Mobile (mortality 1,191), Cahawba, Citronelle, Demopolis, Fulton, Hollywood, Montgomery (mortality 55), Selma (mortality 32), were the principal towns visited by the scourge. In *Louisiana* the disease prevailed at New Orleans, with a mortality of 7,970, at Alexandria, Algiers, Bay St. Louis, Baton Rouge, Centreville, Clinton, Donaldsonville, Franklin, Opelousas, Pattersonville, Plaquemine, Shreveport, Thibodeaux, Trenton, Washington, and various smaller places. In *Mississippi*, Biloxi, Brandon, Clinton, Grand Gulf, Greenwood, Jackson, Natchez, Pascagoula, Pass Christian, Port Gibson, Washington, Woodville, Yazoo. In *Arkansas* Columbia, Grand Lake, Napoleon. In *Texas* Brownsville, Cypress City, Galveston, Hockley, Houston, Indianola, Liverpool, Richmond, Sabine.

1867.—The epidemic of this year was widely extended in the State of Texas. The first recognized case in New Orleans occurred on the 10th of June. The total mortality in this city was 3,093. Other towns visited in Louisiana were New Iberia and Opelousas. In *Texas* the first cases occurred at Galveston on the 25th of June, and the total mortality in this city was 1,150. Other places visited by the epidemic were Alleyton, Anderson, Austin, Bastrop, Brenham, Calvert (mortality 250), Chapel Hill (mortality 128), Corpus Christi, Danville, Goliad, Hempstead (mortality 151), Huntsville (mortality 150), Independence, Indianola (mortality 80), La Grange (mortality 200), Liberty, Millican, Navasota (mortality 154), Oldtown, Port Lavaca, Rio Grande City (mortality 150), Victoria (mortality 200).

1873.—Florida, Alabama, Mississippi, Louisiana, and Texas again suffered from an epidemic of yellow fever in the year 1873. At Pensacola, Fla., the first recorded case occurred August 6th, and the total mortality was 61. In *Alabama* the disease appeared at Mobile on the 21st of August, and the total mortality was but 27. Montgomery suffered a loss of 102. In *Louisiana* the mortality in the city of New Orleans was only 225, although the epidemic had its origin in this city. It was imported by the Spanish bark Valparaiso, which sailed from Havana, June 15th, in ballast, arrived at the New Orleans quarantine station June 24th, was detained two days, and came to the city June 26th. The first case was the mate of this vessel, who was taken sick on board July 4th, while she was lying at the wharf. But for the sickness and death of the mate of the Valparaiso, the origin of this epidemic would have remained obscure, and the believers in the local origin of the disease would have had a strong case, for no other cases of the disease occurred on the Valparaiso. This is explained by the fact that the crew consisted of acclimated Spaniards, and the mate seems to have been the only susceptible person on board who could serve as a test of the infection of the vessel at her port of departure. From New Orleans the disease was carried to Memphis by the river steamer Bee. It caused a mortality in this city of 2,000. River steamers from New Orleans also carried the disease to Shreveport, La., where the mortality was 759. From Shreveport a refugee fled to the town of Calvert, Tex., where he was taken sick and died; an epidemic followed with a total mortality of 125. The disease was also introduced by refugees to the town of Marshall, Tex., where 36 deaths occurred. The epidemic of this year at Pensacola, Fla., was due to an independent importation by the ship Golden Dream, and Montgomery, Ala., became infected through refugees from Pensacola.

1878. The last and most extended epidemic of yellow fever in the United States is that of 1878, which invaded

132 towns, and caused a mortality of 15,934, out of a total number of cases exceeding 74,000.

The origin of this epidemic was traced by the president of the Louisiana State Board of Health (Chopin) to the steamer Emily B. Souder, which arrived from Havana May 23d, and was moored at the foot of Calliope Street, New Orleans. Dr. Chopin says: "The first cases of yellow fever in New Orleans in 1878 were, undoubtedly, two of the officers of the above steamship, namely, Clarke, the purser, and Elliott, one of the engineers. Infected centres were developed in the vicinity of the houses in which these men were sick, but not until after an interval of several weeks, during which, probably owing to unfavorable conditions as to temperature, the 'germs' remained dormant, or at least multiplied so slowly as not to cause an outbreak of the disease."

Fortunately, this great epidemic has been carefully studied by a "Board of Experts, authorized by Congress," and we have a very complete history of its geographical extension, and of the deadly results which marked its course. The following data are from the report of this "Board of Experts."

Louisiana.—New Orleans mortality, 4,600; Allemands Station, 17; Baton Rouge, 193; Bayou Cypre, 7; Berwick City, 7; Buras Settlement, 3; Clinton, 15; Delhi, 34; Delta, 47; Donaldsonville, 71; Gretna, 53; Hammond, 5; Henderson, 18; Houma, 6; Jesuits Bend, 2; Labadieville, 24; La Fourche, 26; Lagonda and other plantations, 42; Morgan City, 100; Napoleonville, 8; Paincourtville, 15; Pattersonville, 47; Pilot Town, 17; Plaquemine, 125; Ponchatoula, 3; Port Eads, 13; Port Hudson, 11; St. Bernard Parish, 7; Tangipahoa, 50; Thibodeaux, 65; Teche Country plantations, 81.

Tennessee.—Bartlett, 9; Brownsville, 212; Chattanooga, 135; Colliersville, 56; Germantown, 35; Grand Junction, 74; La Grange, 37; Martin, 40; Mason, 24; Memphis, 5,000; Milan, 12; Moscow, 35; Nashville, 6 (all imported cases); Paris and suburbs, 23; Somerville, 57; White Station, 50; Williston, 11.

Alabama.—Decatur, 44; Florence, 50; Huntsville, 12; Leighton, 1; Mobile, 90; Stevenson, 6; Town Creek, 4; Tuscaloosa, 2; Tuscumbia, 31.

Mississippi.—Bay St. Louis, 82; Benton, 1; Biloxi, 45; Bolton, 34; Bovina, 7; Brown's plantations, 4; Canton, 180; Vicinity of Canton, 47; Dry Grove, 41; Friar's Point, 7; Gainsville, 2; Goodrich Landing, 12; Greenville, 301; Grenada and vicinity, 343; Horn Lake, 2; Handsboro, 16; Hernando, 80; Holly Springs, 309; Iuka, 3; Jackson, 86; Lake, 86; Lebanon, 10; Livingston, 10; McComb City, 21; Meridian, 91; Mississippi City, 15; Ocean Springs, 30; Osyka, 45; Pass Christian, 23; Pearlington, 24; Port Gibson, 115; Country about Port Gibson, 150; Refuge Landing, 11; Rocky Springs, 38; Scranton, 20; Stoneville, 15; Spring Hill, 6; Sulphur Springs, 5; Senatobia, 7; Terrene, 4; Vicksburg, 872; Vicinity of Vicksburg, 300; Water Valley, 64; Winona, 3; Winterville and vicinity, 26; Yazoo City, 9.

Kentucky.—Bowling Green, 19; Hickman, 153; Louisville, 64 (mostly refugees).

Ohio.—Cincinnati, 17 (refugees); Gallipolis, 18.

Illinois.—Cairo, 51.

Missouri.—St. Louis, 16; Quarantine (near St. Louis), 42.

ETIOLOGY.—The preceding historical record shows that in the United States, as elsewhere, yellow fever has prevailed more frequently in seaports than in inland towns, and that, when epidemics prevail in the interior, their origin can commonly be traced to the nearest seaport, or to intermediate towns in communication with it. Towns upon or near the coast which have no commerce are no more subject to invasion by yellow fever than are interior towns, unless it be by reason of their proximity to a seaport. Moreover, the frequency of epidemics in our southern seaports, before the era of efficient quarantine administration, bears a direct ratio to their commercial importance, and especially to their commercial intercourse with Havana or other endemic foci of the disease. Thus New Orleans suffered epidemics of greater or less magnitude in 48 out of the first 60 years of the present century. During the same period (1800–1860) Charleston suffered 28 epidemics; Mobile, 22; Pensacola, 17; Savannah, 9; Galveston, 7. That local conditions are favorable for the development of an epidemic at many of our interior towns, especially those located on great rivers, near the sea-level, in the Southern States, is amply proved by the epidemic of 1878. That yellow fever does not occur at these towns, except as a result of the introduction of infected persons or articles, is beyond question. So, too, in sea-port cities there is no reason for believing that any radical change has occurred in local conditions during the past twenty-eight years; yet during this time New Orleans has only suffered 6 epidemics, while during a corresponding period (twenty-eight years) prior to 1860 there were twenty-two years of epidemic prevalence of the disease. A similar comparison for Charleston shows fourteen years of epidemic prevalence prior to 1860, and only one since.

Up to the year 1860 there were many advocates of the *local origin* of the disease in these seaports, and the disease was considered endemic by many physicians, both in Charleston and in New Orleans. But to-day scarcely anyone questions the fact that the disease, notwithstanding its frequent prevalence, was due to importation, and that it is nowhere endemic within the boundaries of the United States. It is not improbable, however, that in certain instances the "germs" of the disease have survived the winter season, and that "sporadic cases" and epidemics have occurred as a result of importation, dating back one or more years. It is claimed that the epidemic of 1879, in the city of Memphis, was not due to a new importation, but resulted from the hibernation of germs in houses infected in 1878. Dr. Thornton, President of the Memphis Board of Health during these epidemics, says: "The disease appeared in houses in the suburbs, which were infected last year;" and states further that the first case reported to the health office occurred on the 8th of July, at which date the disease was not prevailing in any part of the United States. In New Orleans, in epidemic years, cases have sometimes continued to occur during the greater part of the month of December, and in Tampa and Plant City, Florida, where yellow fever was epidemic in the summer of 1887, cases are said to have occurred at intervals throughout the winter. Admitting, then, the probability that the recurrence of the disease in our southern seaports has sometimes been due to the preservation of infectious material in an active state throughout the winter, we must insist, nevertheless, that there is no satisfactory evidence of the *de novo* origin of the disease from local causes, either in our own country or elsewhere; and that, wherever its original habitat may have been, the prevalence of the disease within the period to which our authentic historical records relate has been due to the importation of cases, or of infected material, from a previously infected place. In other words, the disease is due to a specific infectious agent.

As to the nature of the *specific cause* of the disease there can scarcely be two opinions. The present state of science justifies the belief that it is a living micro-organism; and facts relating to the origin and extension of epidemics show that, as in cholera and in typhoid fever, this micro-organism is capable of development outside of the human body under favorable conditions, which will be discussed hereafter. Unfortunately, the present state of science does not enable us to give an account of the exact nature of the deadly *microbe* which we assume to be the cause of the disease under consideration. We know to-day the morphological and physiological characters and the habitat within the body of an infected individual of the specific cause of cholera, of typhoid fever, and of relapsing fever, but the researches made up to the present time have failed to demonstrate the "germ" of yellow fever.

In 1879 the writer went to Havana, as a member of a commission appointed by the National Board of Health, for the investigation of questions relating to the etiology of yellow fever. One of the main objects in view in the appointment of this commission was the discovery, if possible, of the specific cause of the disease.

The commission was fully equipped with the best microscopical apparatus and with whatever else seemed necessary to promote the accomplishment of the object in view.

Examination of the Blood for Micro-organisms.—The prevailing opinion with reference to the pathology of yellow fever, and the fact that in anthrax and in relapsing fever the specific micro-organism is found in the blood, led to the assumption that the same might be true in yellow fever. Accordingly, the writer devoted himself especially to the examination of this fluid. The result was entirely negative, and is stated as follows in the Preliminary Report of the Commission:

"The patients from whom specimens of blood were obtained were mostly soldiers in the military hospital of San Ambrosio. Ninety-eight specimens, from forty-one unselected cases of yellow fever, were carefully studied, and one hundred and two photographic negatives were made which show satisfactorily everything demonstrable by the microscope. These photographs were mostly made with a magnifying power of 1,450 diameters, obtained by the use of Zeiss' 1/18 homogeneous oil-immersion objective and Tolles' amplifier. Probably no better lens than the Zeiss' homogeneous oil-immersion could have been obtained for this work, and it is doubtful whether any objective has ever been made capable of showing more than is revealed by this magnificent lens. With the power used, organisms much smaller than those described as existing in the blood of anthrax or of relapsing fever would be clearly defined.

"If there is any micro-organism in the blood of yellow fever, demonstrable by the highest powers of the microscope as at present perfected, the photo-micrographs taken in Havana should show it. *No such organism is shown in any preparation photographed immediately after collection.* But in certain specimens kept under observation in culture-cells, bacilli (?) fungi and spherical bacteria made their appearance after an interval of one to seven days. The appearance of these organisms was, however, exceptional, and in several specimens taken from the same individual at the same time it occurred that in one or two a certain fungus made its appearance and in others it did not. This fact shows that the method employed cannot be depended upon for the exclusion of atmospheric germs, but does not affect the value of the result in the considerable number of instances in which no development of organisms occurred in culture-cells in which blood, in a moist state, was kept under daily observation for a week or more."

The method employed seemed the only one practicable for obtaining blood from a large number of individuals without inflicting unwarrantable pain and disturbance upon the sick. It was as follows: "One of the patient's fingers was carefully washed with a wet towel (wet sometimes with alcohol and at others with water), and a puncture was made just back of the nail with a small triangular pointed lancet. As quickly as possible a number of thin glass covers were applied to the drop of blood which flowed, and these were then inverted over shallow cells in clean glass slips, being attached usually by a circle of white zinc cement."

The method as above detailed was imperfect, on account of the fact that the finger from which blood was obtained was not properly sterilized; and if positive results had been reported the criticism would have made it unsafe to draw the conclusion that micro-organisms developed in these culture-cells had their origin from others of the same sort present in the blood of the individual. Subsequent researches have demonstrated the fact that, even when the finger is carefully washed with a 1 to 1,000 solution of mercuric chloride, sterilization of the surface is not always secured. Thus during the past year, in Rio Janeiro and in Vera Cruz, I have repeated my culture experiments with blood drawn from the fingers of patients in various stages of the disease. But in these more recent experiments I have carefully washed the finger, first with soap and water, then with a 1 to 1,000 solution of mercuric chloride, and finally with alcohol to remove the bichloride of mercury. The blood in these experiments was introduced with proper precautions into various culture-media in test-tubes—nutrient flesh-peptone gelatin, solidified blood-serum, peptonized bouillon. Out of a total of thirty-four test-tubes inoculated in this way with blood from five typical cases of the disease, twenty-eight remained sterile, while various organisms appeared in six.

If the same micro-organism had presented itself in the six exceptional tubes, one might suppose that it came from the blood of the patients, and that failure to develop in the others was due to the fact that it was not constantly present in the circulating fluid, as is the case in typhoid fever, for example, in which disease the bacilli are found in the spleen, the lymphatic glands, the liver, and the kidney, but are only exceptionally present in the blood of the general circulation. But in this series the six exceptional tubes contained different micro-organisms, and the inference is that they were present as a result of accidental contamination of the blood drawn, either by micro-organisms on the surface of the finger not destroyed by the disinfecting agents, or by floating atmospheric organisms attached, perhaps, to epithelial cells or to minute particles of dust, etc., which are extremely abundant in the atmosphere of hospital wards.

It would not be safe, from these experiments with blood drawn from the finger alone, to infer that there is not present in the blood or tissues a specific micro-organism in this disease. Evidently, the solution of this question requires a careful study of stained sections of the various organs, and especially of those which show the most constant pathological changes—liver and kidney.

Examination of the Tissues for Micro-organisms.—In the infectious diseases which have been proved to be due to the presence of a parasitic micro-organism in the blood, this organism may be demonstrated in properly stained thin sections of the tissues. In such sections we frequently obtain cross-sections of small blood-vessels in which the blood corpuscles are *in situ*, and in which a stained micro-organism, if present, would be very apparent. We also have a very satisfactory view of the contents of the capillary vessels of the various organs, as well as of their cellular histological elements. Pathologists therefore look upon a careful research by the methods which have been perfected with this object in view, as of prime importance in any attempt to prove whether a given infectious disease depends upon the presence in the blood of a specific micro-organism. The Havana Commission adopted this method, and numerous sections were made by Dr. Guiteras, a member of the Commission. A careful study of these gave an entirely negative result so far as the presence of micro-organisms is concerned. But inasmuch as new and valuable methods of staining have been devised since the date of the research referred to, the writer has considered it important that further investigations in this direction should be made, and during the past three years he has made a very large number of preparations, chiefly from the liver, the kidney, the stomach, and the intestine. These have been stained in various ways and have been carefully studied. The material employed in this research has been obtained from Havana, and the autopsies there were all made within a short time after death—one to three hours. The sections were stained by various methods, but chiefly with Löffler's alkaline solution of methylene blue, by Gram's method, and by the method of Weigert.

The result of this research has been negative so far as the general presence of any particular micro-organism is concerned. But in one case I found in the kidney a minute bacillus which apparently invaded by preference the glomeruli. It was not found in the capillaries generally, but a certain number of foci were seen in the sections, as shown in Fig. 5067. These involved a portion of a glomerulus as seen in the figure, or in certain instances a whole glomerulus and the tissues immediately surrounding it. The appearance was such as one would expect to see in a case in which solitary bacilli, carried in the first place by the blood-current, had ef fected a lodgement and established a centre of infection in tissues already, perhaps, necrotic. The exceptional appearance of this bacillus (in a single case) justifies the opinion that it is some common saprophyte which had effected a lodgement in the kidney, probably during the last hours of life, when the vital resistance of the tissues was slight; or when, possibly as a result of blood stasis in the organ, local necrosis had already occurred at certain points before death. It is quite probable that during the last hours of life, in this and in other diseases, a certain number of micro-organisms from the intestine succeed in passing through the enfeebled tissues to the interior of the capillaries, and are thus distributed throughout the body, ready to produce those putrefactive changes which occur so promptly in hot climates. This view is supported by the results of my recent culture experiments with material obtained from the interior of the liver and kidney as soon as possible after death, which will be given hereafter. I have, in one instance, encountered a group of slender bacilli in the liver, and, in the course of my extended observations, seen two or three groups of micrococci, or what appeared to be micrococci; but I attach no importance to these observations. Evidently, any organism concerned in the etiology of an infectious disease should be found, not occasionally and in certain cases only, but if seen at all by the staining methods adopted, it should be found distributed through the organs involved in sufficient numbers to leave no doubt as to its presence, not as an accident, but as a general and constant thing in all cases of the disease under investigation.

Extracts from an unpublished report to the President of the United States, submitted June 22, 1888:

"Having heretofore failed to find any specific micro-organism in the blood and tissues of yellow fever cases by the methods detailed in my previous report, I desired to test the reliability of this negative result by inoculating various culture-media with material obtained from the interior of the organs which show the principal pathological changes in this disease—liver and kidney—and with blood drawn from the cavities of the heart, and urine obtained through the walls of the bladder, at the earliest possible moment after death. . . .

"In four cases, at the time of making the autopsy, I have taken pieces of liver and kidney of considerable size, and have enveloped them in many folds of muslin, or of tissue paper, saturated with a one per cent. solution of mercuric chloride. These pieces were kept in the laboratory for forty-eight hours, and at the end of this time the antiseptic wrapping was removed and material obtained from the interior, by making an incision with a sterilized knife. In every case I obtained positive results from my cultures made from this material, although the same liver and kidney had given me negative results in cultures made immediately after death. These pieces of liver and kidney were perfectly antiseptic so far as the exterior was concerned, but the effect of the bichloride solution was quite superficial, as could be seen by the whitish color of that portion of the tissue which had been acted upon, and in which, no doubt, the albuminous material had served to neutralize the mercuric solution, and to prevent its further penetration. The interior of the pieces, on the other hand, preserved its fresh appearance, and on staining a little of this fresh-looking material it was found to contain numerous and various micro-organisms."

This must be taken as evidence that, notwithstanding the negative results of my cultures from the same material made immediately after death, micro-organisms were present in the tissues, but in such limited numbers that, until time was given for their multiplication, they were not likely to be discovered either by the microscopical examination of stained sections, or by the method of cultivation.

Results of Culture Experiments.—The general results of my culture experiments are as follows:

"*Blood.*—In eight of the ten cases, my cultures from blood drawn from the heart have remained sterile. This result fully confirms the conclusion heretofore reached by the method of direct examination and cultivation of blood drawn from the finger of patients during life. In the two exceptional cases a few colonies appeared, in one my bacillus *a*, to be described hereafter; in the other bacillus *a* and another bacillus resembling it in its morphology, but shown to be different by the appearance of its colonies in gelatine."

"*Urine.*—In seven cases my cultures from urine drawn through the walls of the bladder have remained sterile; in three cases micro-organisms were present." . . .

"*Kidney.*—In six of the ten cases I have obtained micro-organisms from the kidney, and in four cases my cultures remained sterile." . . .

"*Liver.*—In seven cases my cultures from the liver have remained sterile, and in three they have given me colonies."

I may say here, that in those cases in which my cultures, in Esmarch tubes, from the blood, urine, kidney, and liver, gave a positive result, several different micro-organisms were encountered, the most common form being the bacillus which I have designated with the letter *a*, and which appears to be identical with the bacillus found by Emmerich in cholera cadavers, at Naples, in 1884. I have not yet determined definitely the question of identity, however, and must reserve my opinion until I have an opportunity of making a careful comparison of the micro-organisms from the two sources. If my bacillus *a* is indeed identical with the bacillus of Emmerich, it must be excluded as a specific etiological agent in yellow fever. Considering, however, the close resemblance of the spirillum of Asiatic cholera with the spirillum of Finkler and Prior, and that of Deneke (cheese spirillum), it is evident that this question cannot be settled upon morphological grounds alone. Its occasional presence in the tissues cannot alone be accorded any great weight, but considered in connection with the fact that, in my cultures from the contents of the stomach and intestine, I found it to be the most abundant organism, and present in all of the cases, it becomes a matter of great interest to know whether it is identical with any known micro-organism found in the same situation in health or in other diseases. I am called upon to write this paper before this question is definitely settled, but I may say now that I strongly suspect that my bacillus *a* is identical with the bacillus of Emmerich, which for a time he supposed to be the specific cause of cholera. I may remark here, that in my cultures from the contents of the stomach and intestine of ten cases of yellow fever, I have not encountered any micro-organism resembling the cholera spirillum of Koch.

In none of my cultures from the blood and tissues have I encountered a micro-organism corresponding with the *cryptococcus xanthogenicus* of Dr. Domingos Freire, of Brazil. The conclusions reached as a result of the investigations recently made in Havana, are formulated in my report as follows:

"The specific cause of yellow fever has not yet been demonstrated.

"It is demonstrated that micro-organisms capable of development in the culture-media usually employed by bacteriologists, are only found in the blood and tissues of yellow fever cadavers in exceptional cases, when cultures are made very soon after death."

Can we accept the evidence presented as conclusive as to the absence of any specific micro-organism in the blood and tissues? It may be supposed that the "germ" we are in search of is ultra-microscopic, or that it will not grow in the culture-media which have been employed. I would reply to the first hypothesis, that an ultra-microscopic bacterium capable of growth in our culture-media would form colonies visible to the naked eye, and that in all the experience of bacteriologists no such ultra-microscopic micro-organism has been encountered. As to the hypothesis that a germ is present which will not grow in our culture-media, this is opposed by the fact that no micro-organism has been demonstrated to be constantly present, by the extended researches made by myself and others, in which thin sections of the various organs have been examined, after having been stained by those methods which are the most successful in such researches. Moreover, all of the evidence relating to the epidemic extension of yellow fever points to a micro-organism capable of rapid development in filth-laden outside of the human body, as is the case with the spirillum of cholera, and the bacillus of typhoid fever; and such a micro-organism ought not to be difficult to cultivate in artificial media. Unless, indeed, it should prove to be an anaërobic organism, in which case special methods of cultivation, not yet employed in these researches, would be required.

Finally, there is experimental evidence of another kind to show that the specific infectious agent in yellow fever is not present in the blood. The direct experiment has been made of injecting blood drawn from the median vein of a yellow fever patient into an unacclimated individual. This experiment was made, at my request, in Vera Cruz, by Dr. Daniel Ruiz, director of the civil hospital in that city, in September, 1887. The entire contents of a hypodermatic syringe, just filled from the median vein of a patient in the eighth day of the disease, was injected subcutaneously in the deltoid region of an adult negro recently from the interior. In this case the criticism may be made that the febrile stage had passed, and I was extremely anxious to see the experiment repeated with blood from an earlier period. No opportunity, however, offered itself. But Dr. Ruiz states that he had previously (1885) made the experiment in two cases, with an entirely negative result.

The failure thus far to find a specific micro-organism in the blood leads to the supposition that it may be in the alimentary canal, and that, as in cholera, the phenomena of the disease are due to the absorption of a toxic substance formed in the intestine during the active growth of the yellow-fever microbe. In cholera the clinical features of the disease naturally called attention to the alimentary canal as the habitat of the pathogenic micro-organism; and Dr. Koch, having perfected his plate method for the isolation of such organisms, experienced no difficulty in establishing the fact that his "comma bacillus" is uniformly present, and often "almost in a pure culture," in the contents of the intestine of those recently dead from cholera.

In yellow fever, on the other hand, prevailing opinions as to the nature of the disease, and the absence of clinical or pathological features pointing especially to the alimentary canal, have possibly led investigators to neglect this in their bacteriological investigations. In my recent researches in Havana I have, however, given special attention to the micro-organisms found in the stomach and intestine.

As was to have been expected, I have encountered a variety of micro-organisms in my cultures from material obtained post mortem from the alimentary canal. Some of these are common forms which can be obtained by the same method from the stomach and intestine of persons in health, or by those dying from other diseases. The organism which has particularly attracted my attention is my bacillus x, referred to above as occasionally found in my cultures from the liver and kidney.

This bacillus was present in the cultures from material obtained from the intestine in every case (ten), and it was shown to be the micro-organism most abundantly present in the very numerous colonies, compared with all other bacteria present, which developed in Esmarch tubes inoculated with such material. I cannot attempt at present to give a complete account of the various micro-organisms which I have encountered in my cultures. More time will be required to determine their characters with precision.

Bacillus x is from one and a half to four times as long as it is broad, and has a diameter of about one-half of a micromillimetre; the dimensions vary considerably, however, in different cultures, and even in the same culture. Under certain circumstances the ends of the rods are seen to be more deeply stained than the central portion. This appearance is not, however, constant, and seems to depend upon the age of the culture, and upon the time during which it is subjected to the action of the staining reagent. The ends of the rods are more or less rounded, and they are often associated in pairs.

Young colonies in gelatine (Esmarch tubes) have a pale straw-color, which afterward becomes pale brown; they are spherical and homogeneous in interior. Colonies which have come to the surface often present the appearance of a rosette, or of a flower with its petals expanded, as in the daisy. From cultures in which lobate colonies and rosettes were the prevailing form, I have obtained, in a second series of Esmarch tubes made from a single rosette, colonies which were not lobate, and which did not form rosettes (spherical, straw-colored, homogeneous colonies); and in these cultures superficial colonies have the appearance of a fragment of broken glass; later they present an irregular margin, and a more or less wrinkled appearance of the interior. Later these colonies have an irregular, vitreous-looking margin, and the interior has a brown color, more or less intense. These are the characters given by Flügge of gelatine colonies of the bacillus of Emmerich, discovered in cholera cadavers at Naples in 1884; and the morphology of this bacillus, as given by Flügge, resembles that of the bacillus which I have found as the prevalent form present in the intestine of yellow-fever cadavers in Havana. Weisser, who has made an extended study of the bacillus of Emmerich, finds that it is present in certain cases in the fæces of healthy individuals, and in the intestinal contents of those dying from other diseases than cholera, and that, therefore, the claim of Emmerich that it is the specific microbe of cholera was unfounded. He also showed that a micro-organism very similar to it, and which can only be differentiated by the appearance of its colonies in certain culture-media, is found quite constantly in the large intestine of healthy persons. The history of the spirillum of Asiatic cholera—"comma bacillus" of Koch—and of other spirilla which closely resemble it—Finkler-Prior spirillum, Deneke's cheese spirillum—shows that it is not safe to assume identity upon morphological grounds, and that even in their colonies in gelatine and in their mode of development, micro-organisms which are specifically different may resemble each other very closely. Since the above was written I have made an extended series of experiments with reference to this bacillus x, and believe it to be identical with the Naples bacillus of Emmerich, and with the *Bacterium coli commune* of Escherich.

The material which has served for my cultures from the intestine has usually been obtained from the ileum, where the characteristic black matter is the most abundant—sometimes as a fluid filling the lumen of the intestine, but more frequently as a viscid material, from admixture with mucus which adheres to its walls.

I have also made numerous cultures from vomited material obtained at the bedside of patients—both black vomit, "coffee-ground vomit," and the colorless fluid ejected in many cases during the first days of the attack. These cultures have given very various results. My bacillus x has been present in some cases; in certain cases a torula has been the most abundant organism present. In one case I obtained a short bacillus in chains resembling that of Babes. In one case, in which the vomited matter was alkaline, the cultures contained a great variety of bacilli and micrococci. On the other hand, cultures from several specimens of highly acid black vomit remained sterile.

The microscopical examination of stained specimens of the material from the intestine, and particularly from the stomach, shows the presence of a variety of micro-organisms, some of which did not appear in my cultures. Thus the various micro-organisms of the mouth, the entrance of which may be recognized by the fact that they are attached to the epithelial cells from the buccal mucous membrane, do not as a rule develop in our culture-media under ordinary conditions.

If by exclusion we should finally ascertain that there is no specific micro-organism in the body of the victims of yellow fever, we have left the supposition, already entertained by some authors, that the attack is due to the toxic action of a volatile chemical poison produced in infected localities external to the human body. In this case we might suppose that a specific micro-organism, capable of developing in a suitable nidus, under certain conditions as to temperature, etc., produces a volatile ptomaine which, being respired by a susceptible individual, gives rise to the morbid phenomena which characterize the disease. Certain facts favor this view, but others seem to make it untenable. On the one hand, it is well known that the incubation period is often very brief, and that the attack may occur within twenty-four hours after exposure in an infected locality. We have also ample evidence that the disease may be contracted by respiring an infected atmosphere. Indeed, I know of no satisfactory evidence that it is ever contracted in any other way, *i.e.*, by the use of infected water or food. Moreover, it has frequently been observed that persons sleeping near the ground are more subject to attack than those occupying apartments elevated some distance above the ground. During the epidemic prevalence of the disease, it has several times been noted that persons living within an enclosure surrounded by a high wall, as prisoners in jail, escape attack, although their food and water is from the same source as that used by individuals outside of the enclosure. In infected cities, like Havana, which have a common water-supply, there is no evidence that susceptible strangers contract the disease by drinking this water, or through contaminated articles of food. But in such cities there are localities which are the favorite resort of the disease during its epidemic prevalence, and in which it remains, to give evidence of its endemic presence throughout the winter months. It is by visiting these infected localities that strangers, as a rule, contract yellow fever in Havana, Rio Janeiro, and other seaports in which it prevails annually. In this respect yellow fever seems to differ essentially from cholera and typhoid fever, which are propagated largely through the use of contaminated drinking-water. This seems to be opposed to the view that, as in the diseases mentioned, yellow fever is due to a micro-organism which multiplies in the intestine, for in this case we should expect to encounter local outbreaks directly traceable to the contamination of a common water-supply. That this never occurs we cannot assert, but, as stated, I know of no evidence in support of the view that the disease may be transmitted in this way. There are numerous instances, however, of attacks occurring after a brief visit to an infected locality, and presumably as a result of breathing an infected atmosphere. These facts give some support to the view that the attack is a direct result of intoxication by a volatile chemical poison, as maintained by Corré and others. But, on the other hand, the period of incubation is often prolonged to three or four days after removal from the infected locality, and, it is difficult to account for this delay in the development of the morbid phenomena upon the theory under consideration. Then, too, there is ample evidence to show that yellow-fever patients establish new centres of infection when the external local conditions are favorable, and that the bedding used by them, even after a long interval, contains the infectious agent—as proved by the fact that susceptible persons who handle it may contract the disease directly from such infected bedding, or that it may serve for the development of new foci of infection in distant localities to which it has been transported. This fact again brings yellow fever into line with cholera, and gives support to the hypothesis that the specific infectious agent is present in or about the body of the sick.

The supposition that it multiplies upon the surface of the body and produces a poisonous ptomaïne, which is absorbed through the skin, would account for the infection of the bedding; but there is nothing to support this supposition in our knowledge of other infectious diseases, and it seems to be untenable in view of the fact that the disease is not transmitted by personal contact. There is abundant evidence in support of this statement, which will be referred to hereafter.

The explanation that the bedding is infected by the alvine discharges of the sick does not appear as satisfactory as it is in cholera and typhoid fever, which diseases are characterized by frequent liquid discharges from the bowels. But in fatal cases of yellow fever a dark-colored fluid, similar to the "black vomit," is frequently discharged from the bowels, and the bedding is liable to be soiled with it as well as with the contents of the stomach, which in the later stages of the disease are often ejected with great force at a time when the patient is lethargic or quite unconscious.

MICRO-ORGANISMS which have been described as the specific cause of yellow fever:

Cryptococcus xanthogenicus of Dr. Domingos Freire, of Brazil. In his principal work, published in 1885, Dr. Freire gives the following account of his cryptococcus: "When we follow with care and attention the march of the development which characterizes the germs which produce yellow fever, we acquire a certainty that, commencing to present themselves under the form of little points almost imperceptible, they afterward gradually increase in diameter until they attain considerable dimensions; so that the little beings, which at the outset had the appearance of little grains of sand, not measuring more than 0.001 millimetre to 0.002 millimetre in diameter, arrive little by little to such a development that they reach the dimensions of 0.005, 0.007, 0.008 millimetre, and sometimes even more in certain conditions. When they have attained the adult age, these cells are broken at divers points, and discharge their contents, composed of spores already formed, mixed with a viscous substance of a yellow color, composed of a pigment and protoplasmic substance, and of the liquids elaborated by the cells."

In an address delivered in Paris in 1887, Dr. Freire repeats this account of the mode of development of his cryptococcus; he says: "Each adult cell is ruptured at one or several points, and allows to escape its contents, composed of germs which are to perpetuate the species, and two pigments—one yellow, destined to infiltrate the tissues, and to produce the icteric color which has given name to the malady; the other black, insoluble, and destined to be carried along the circulatory current, producing either capillary obstructions or blood stasis in the parenchyma of the organs."

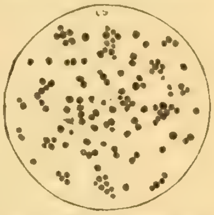
FIG. 4665.—Micrococcus of Freire. Culture brought from Paris in 1887, and presented to the writer as the microbe of yellow fever. Drawn from a preparation made in Dr. Freire's laboratory. × 1,000.

This account is entirely fanciful, and is evidently based upon erroneous observation and misinterpretation of what has been seen under the microscope, and to imperfect methods of research. No such micro-organism as Dr. Freire has described is known to bacteriologists, and certainly nothing of the kind is to be found in the blood and tissues of yellow-fever cases, as Dr. Freire asserts.

At the time of my visit to Brazil (1887), Dr. Freire, who had just returned from France, presented to me, as his yellow-fever germ, a liquefying staphylococcus. This had been isolated from his impure cultures in bouillon by a French bacteriologist, Dr. Paul Gibier. Like other micro-organisms of the same class, it multiplies only by binary division, and having cultivated it in various media, I can say with confidence it does not form a black or a yellow pigment, and consequently does not correspond with the *cryptococcus xanthogenicus* as previously described by Dr. Freire. Nor is it found in the blood and tissues of yellow-fever patients.

Peronospora lutea of Dr. Carmona y Valle. In Dr. Carmona's work, published in 1885, the following account is given of his yellow-fever microbe:

"Admitting but two phases in the development of the fungus which produces yellow fever, I shall recapitulate the succession of the phenomena which occur in order to fix them well in your memory.

"Let us take as point of departure the urine eliminated by yellow-fever patients. It contains, as you know, a great number of zoospores, or very small granulations endowed with proper movements, and which only measure a thousandth of a millimetre in diameter. These granulations unite in pairs, and (that is, later) they unite into a single one which grows gradually. This element appears and assumes a glistening yellow color by reflected light, and greenish and as glassy by refraction. Some of these appear, the dimensions of which are more considerable, attain sometimes 1/5 of a millimetre in diameter. They [illegible] in many cases, being [illegible] to dissolve tissue and in other compensatory processes to produce the cases under which we have observed. The spores of this organism penetrating into the animal economy, give birth in a proportion to the cryptococcus elements which appear a great number of [illegible] filled with cryptococci. When the [illegible] are examined the cryptococci are distributed throughout the structure."

At the time of my visit to Rio de Janeiro (1887) Dr. Carmona had modified his views as to the morphology of the yellow fever parasite. He had given up the spores and the (mycelial or filamentous) forms of the "cryptococcus" found in the urine, but believed that these conidiæ developed into rods—bacilli—and that these again produced the cryptococcus. He was kind enough to show me a stained preparation of the cryptococcus and of the bacilli, and to give me cultures of the same. The so-called cryptococcus were in fact micrococci, which do not differ in their morphology from those constantly found in urine which has undergone alkaline fermentation. Evidently Dr. Carmona's inference, that the micrococcus and the bacillus which developed in his cultures from the same source represent different phases in the development of the same micro-organism, is a mistake.

My recent researches in Havana show that, as a rule, culture-media inoculated with urine drawn through the walls of the bladder, immediately after death, remain sterile. In seven cases out of ten this was the result, while in three cases micro-organisms developed. In one my bacillus x associated with at least two other bacilli; in one a liquefying bacillus which forms a green pigment; in one a common putrefactive bacillus.

The Bacillus of Lacerda and Babes.—In 1883 Dr. Lacerda, of Rio Janeiro, having discovered what he believed to be micro-organisms in the liver and kidney of yellow-fever cases, sent some of the material to Paris, to Dr. Babes. This bacteriologist distinguished the presence of a micrococcus (in the material), and described it as follows:

"The filaments appear solid and homogeneous with a magnification of 600 diameters, but with a high power (1/18 hom. im. or No. 12 of Vérick, which corresponds with the 1/12 of Zeiss) one can assure himself that these filaments are composed of elliptical grains, almost cylindrical, arranged in pairs, forming little groups in which they are united by an intermediary pale substance. The filaments are thus composed of diplococci or, if one wishes, of very short rods with rounded angles."

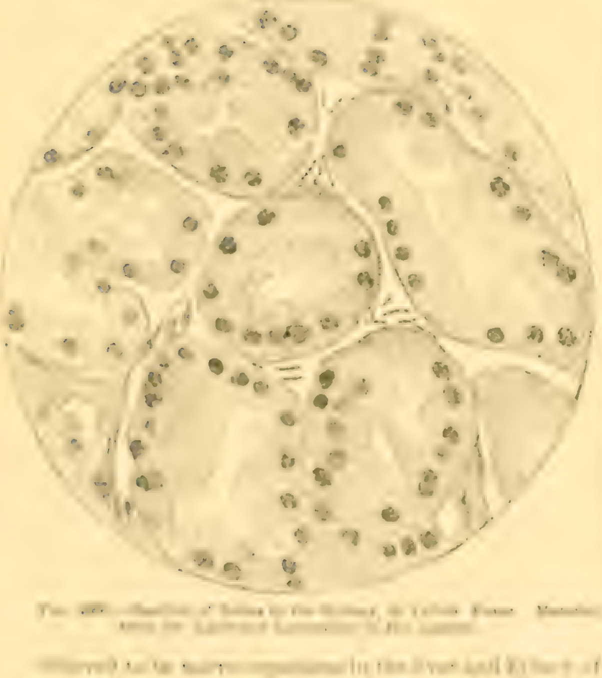

FIG. 4866.—Bacillus of Babes in the Kidney, in Yellow Fever. Magnified [illegible] Lacerda's Laboratory in Rio Janeiro.

Dr. Lacerda has described the organism referred to as in filaments which branch dichotomously, and believes this branching to be a constant and distinctive characteristic of the parasite which he accepts as the veritable yellow fever microbe. He is without doubt mistaken. The apparent branching of the filaments which he has described and drawn, and which he showed me in some of his preparations at the time of my visit to Rio, is due simply to the accidental juxtaposition of the bacilli-like chains. He is also mistaken in supposing that this organism is only to be satisfactorily demonstrated by Gram's method of staining. My friend Dr. Goes shared this belief at the time of my visit to Rio, but I demonstrated to him the facility with which the organism may be stained with a solution of methyline blue, upon sections which he made for me from material in Dr. Lacerda's laboratory. Since my return to Baltimore, I have made numerous sections from the same material, and find no difficulty in staining the organism present in the tissues with methyline blue or with fuchsin.

This bacillus, which is easily demonstrated, I have not been able to find in the tissues of six undoubted cases of yellow fever sent to me from Havana, and which I have carefully studied during the past year.

Babes himself has renounced the idea that this micro-organism bears an etiological relation to the disease under consideration. In the second edition of "Les Bactéries" he says:

"Since these researches we have had the opportunity to examine several series of sections from yellow fever. First, the liver and kidney of two individuals dead from this malady, collected by Dr. Alvarez, were examined in the Laboratory of Pathological Anatomy of the Faculty of Paris, without any bacteria having been found; second, material from three cases of yellow fever which Koch was kind enough to confide to one of us. In these last three cases, notwithstanding the most scrupulous research, and notwithstanding the advice of Koch, it was impossible to find the bacilli chains in the brain, the kidneys, the liver, and the spleen. We must suppose, then, that in yellow fever, as in other infectious maladies, microbes are only found in the parenchymatous organs in certain cases, and not in all. The question whether these micro-organisms really constitute the cause of the malady, or simply a complication, is consequently not resolved."

In my cultures from ten yellow fever cadavers in Havana (1888), I have not encountered this short bacillus in culture, except perhaps in a single instance. In my first case I obtained several different micro-organisms from the urine drawn through the walls of the bladder. One of these is a short bacillus with stained ends, which resembles that of Babes (my bacillus [illegible]). It is very aerobic, grows slowly, does not liquefy gelatine, and upon the surface of gelatine or agar forms a rose-pink mass. The colonies in gelatine are spherical and homogeneous.

As the bacillus of Babes was only seen in sections made from alcoholic preparations, it is impossible to establish identity.

In a single case, I have found in sections of the kidney a straight bacillus, which is shown in Fig. 4867. The material was from Havana, and was put into strong alcohol within three hours after the death of the patient. These bacilli were for the most part in the glomeruli; sometimes they were collected in small foci, as seen in the drawing, and at other times the whole glomerulus and the tissues about it were invaded. The presence of this bacillus is quite exceptional, and I attach no importance to the observation, except as showing that invasion of the tissues by a non-specific micro-organism sometimes occurs in this disease during the last hours of life.

Tetragenus febris flavæ of Dr. Carlos Finlay, of Havana. In a paper published in Havana in 1887, entitled *Etiologia y Profilaxis de la Fiebre Amarilla*, Dr. Finlay arrives at the following conclusions:

"In the studies which we have made up to the present time we believe that we have demonstrated:

"1. That the micrococcus tetragenus febris flavæ is the characteristic form of the microbe of yellow fever.

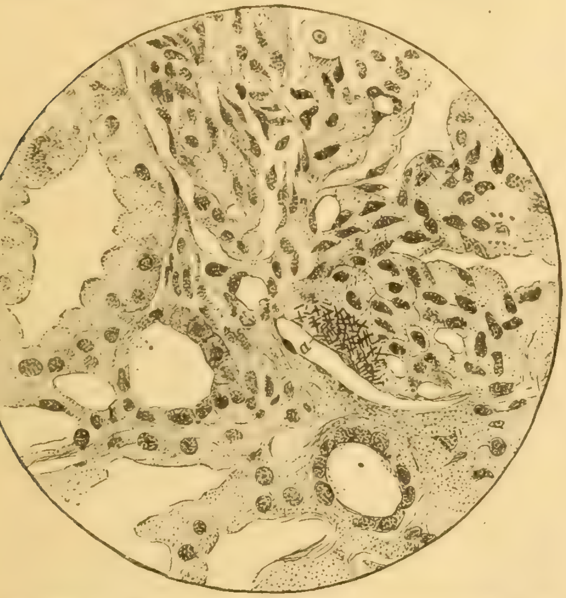

FIG. 4667.—Collection of Straight Bacilli in a Glomerulus of the Kidney in Yellow Fever. Material from Havana.

"2. That the culex mosquito is the known natural agent which transmits this disease.

"3. That, according to the results of our experiments up to the present time, it is possible to protect non-acclimated individuals from contracting *grave* yellow fever by inoculations with the mosquito."

Dr. Finlay kindly sent me some of his cultures from yellow fever blood, and from mosquitoes, in November last (1887), and I spent some time in making a bacteriological analysis of the same. The culture from blood was found to contain the following micro-organisms:

a. Pale-yellow spherical colonies; a large coccus in tetrads and irregular groups.

b. Cream-white colonies, spherical or lobate; a large coccus in tetrads; varies very much in its dimensions and mode of grouping.

c. Pale-white colonies; a small micrococcus in tetrads.

d. Pale-yellow spherical colonies; a short oval bacillus (very common in Havana and elsewhere).

e. A large liquefying bacillus in pairs and chains.

My researches at Vera Cruz and in Havana have shown me that the most common micro-organisms upon the surface of the body of yellow fever patients, and of healthy individuals as well, are micrococci of various species, and that among these the large coccus in tetrads (*a*) which forms yellow colonies, is one of the most common. I therefore infer that the micro-organisms found by Dr. Finlay in his cultures from blood drawn from the finger, and from the mosquitoes which had filled themselves from yellow fever patients, are from the surface and not from the circulating fluid, which has been repeatedly proved by my culture experiments to be free from such micro-organisms. At the time of my visit to Havana (1888), Dr. Finlay, in view of the facts above stated and others, read a paper before the Academy of Sciences in which he substantially withdrew his claim to have discovered the specific cause of yellow fever. He informs me that his *tetragenus febris flavæ* is the micro-organism described above (*b*), which forms cream-white colonies. In my cultures from the blood and tissues of yellow fever cases, I have encountered this in a single instance. It was associated with a liquefying staphylococcus in a piece of kidney which I had kept in the laboratory for forty-eight hours, enveloped in an antiseptic wrapping which insured the exclusion of germs from without.

The Bacillus of Dr. Paul Gibier.—I quote as follows from my report submitted to the President of the United States immediately after my return from Havana (June, 1888):

"In three cases I have obtained from the stomach or intestine a liquefying bacillus (*g*), which appears to be identical with that isolated from material from the same source by Dr. Paul Gibier, who, under instructions from the French government, has been pursuing similar researches during the past six months, in the city of Havana.

"This bacillus, which in the list of micro-organisms that I have encountered, I have designated with the letter *g*, is a long-oval bacillus with rounded or pointed extremities. Like many of the micro-organisms of the same class, it presents under certain circumstances the appearance of end-staining. I see no reason for considering this micro-organism a spirillum, as Dr. Gibier is disposed to do.

"In my cultures it has not presented the character to which he attaches special importance in selecting it as the probable cause of the disease under investigation. Dr. Gibier states that, under certain conditions, this bacillus forms a black pigment which he supposes to be identical with that found in the stomach and intestine of yellow fever patients. As I have no doubt that the pigment in black vomit comes from the blood which has escaped into the stomach by passive hæmorrhage—having repeatedly verified by microscopic examination the abundant presence of the red blood-corpuscles—I do not attach any value to the idea that this pigment is the product of a micro-organism, as has been asserted by Freire, Carmona, and Gibier. Nor have I seen any black pigment in the numerous cultures which I have made of this liquefying bacillus, some of which were made directly from an agar-agar tube which Dr. Gibier kindly presented to me as a pure culture of the micro-organism which he had isolated from the intestinal contents of yellow fever cadavers. It is quite possible that I would have encountered this liquefying bacillus more frequently, if I had used gelatine in all cases as my culture-medium. But in my last case, in which the autopsy was practised within two hours after death, and which was in every way a typical case, I did not encounter this bacillus, notwithstanding the fact that the characteristic black matter from the small intestine (ileum) was put up in a series of gelatine Esmarch tubes.

"Dr. Gibier has reported successful results in inoculation experiments in guinea-pigs, in which he used the black material from the intestine, and in which he assumes that the black matter was the toxic agent—produced by his bacillus—which killed the animals. As the material injected contained a variety of micro-organisms mixed with intestinal mucus, together with the black pigment, and probably more than one toxic ptomaine, it is evident that these experiments cannot be accorded any great scientific value."

This bacillus of Gibier, having been found in the intestine of yellow fever patients in a certain number of cases, stands beside other micro-organisms from the same source as a possible yellow fever germ.

The evidence heretofore recorded has led me, in my last report to the President of the United States, to formulate the following conclusions:

"*The specific cause of yellow fever has not yet been demonstrated.*

"*It is demonstrated that micro-organisms, capable of development in the culture-media usually employed by bacteriologists, are only found in the blood and tissues of yellow fever cadavers in exceptional cases, when cultures are made very soon after death.*"

SUSCEPTIBILITY.—Individuals of every race and of all ages, who are exposed to the yellow fever poison, for the first time. Among the [illegible] of the disease, are sure to be attacked. But there is a wide difference in the degree of this susceptibility among them, some having [illegible] of the same race.

Race.—It has been asserted that the negro race has a complete immunity from yellow fever, but this is a mistake. The susceptibility of the negro is, however, much less than that of the white race, and among those attacked the mortality, as a rule, is small. This is shown by the statistics recorded by [illegible] troops in the British service at West India stations. "While in Jamaica the yearly loss among the troops was [illegible] per 1,000 of the mean strength, the deaths among the blacks did not exceed [illegible] per 1,000. In the Bahamas the proportion of the whites was [illegible] to 1,000, that of the blacks [illegible] to 1,000" (La Roche).

In the report of the Board of Experts appointed by Congress to investigate the epidemic of 1878, we find the following remarks: "[illegible] City: 40 cases among colored, no deaths." "Morgan City, 11 deaths among colored persons." "Brownsville, Tenn.: of 160 colored cases, 15 died." "Chattanooga: of 600 cases, 350 whites, 250 colored; of 134 deaths, 118 whites, 16 colored." "Decatur, Ala.: of 66 white cases, 30 died; of 108 colored, 21 died."

The indigenous races of the West Indies and of the continents of North and South America have no immunity, except such as is acquired by residence in an endemic focus of the disease, and the same is true of the Mongolian race; but like the negro, they have, although to a less degree, less susceptibility than the white race, and the mortality among those attacked is not so great.

In general, it may be stated that the natives of northern latitudes are more susceptible than those born in tropical or subtropical climates. Barr, who had an extended experience in Havana, says: "The lower the winter temperature in the native country of those attacked, the more severe was their sickness; so that, while the mortality among West Indians amounted to only 6.9 per cent. of the sick, it rose to 18.4 among the Italians and French, 23.2 among the English, 28.2 among the Germans and Dutch, and 31.7 among Scandinavians and Russians."

Barton gives the following figures, showing the mortality per thousand among different races, and those of the same race from different latitudes, in the city of New Orleans in the great epidemic of 1853:

		Per thousand.
Born in Orleans		[illegible]
Emigrants from	West Indies, Mexico, and South America	[illegible]
	Southern States of the Union	[illegible]
	Spain and Italy	[illegible]
	Middle States of the Union	[illegible]
	New York and New England States	[illegible]
	Western States of the Union	[illegible]
	France	[illegible]
	British America	[illegible]
	Great Britain	[illegible]
	Germany	[illegible]
	[illegible]	[illegible]
	Austria and Switzerland	[illegible]
	Scandinavia	[illegible]

Sex.—There is probably no difference in the susceptibility of the sexes, but males are attacked in greater proportion than females, because they more frequently and more constantly visit infected localities. The mortality is, as a rule, considerably greater among males. Lopez, in giving an account of the pestilence at Barbadoes in [illegible], of which he was an eye-witness, says: "The cause was unknown; one could not say if the ships of commerce had imported the contagion, or if it came from bad food, [illegible] water, the intemperance of the colonists, and above all, the great quantity of [illegible] which they drank. . . . It was the most debauched who perished first, and not one woman died for ten men." No doubt Lopez was right in ascribing the difference in the mortality of the sexes largely to the difference in their habits with reference to the use of alcoholics. Those who habitually use spirituous liquors are less likely to recover from an attack than the temperate, and a recent debauch is a recognized predisposing cause. Sailors who go on shore at an infected port for "a little spree," very commonly have to go to the hospital, or are taken sick after their return on board ship, and serve as the starting point of an epidemic among their comrades, and subsequently, perhaps, at the port of destination of the vessel. The greater prevalence and severity of the disease, in epidemics, among males has been noticed by numerous authors, and has been verified in the writer's personal experience.

Age.—Infants and old persons enjoy a comparative immunity, due in part, no doubt, to the fact that they are less exposed than active individuals in middle life. Dr. Rush records the fact that he has "met with a violent case of the disease in a child of four months, and a moderate case in a child of only ten weeks" (La Roche). Very young infants, however, commonly escape, or suffer so mild an attack that the nature of the disease is not recognized. In cities like New Orleans, which have suffered repeated epidemics, the proportion of children attacked is often exceptionally large, because they constitute a large share of the unacclimated population, having been born since the last epidemic. Dr. Bemiss has given the following table, showing the number attacked and the comparative mortality for different ages, in the great epidemic of 1878.

The results of private practice in New Orleans are exhibited in the following statistics. Four of the principal practitioners in the city treated, in private practice, 975 patients—909 white and 66 colored. Of the former, 92, or 10.11 per cent., died; of the colored only 2 died. The cases and deaths among the whites, classified by age, are as follows:

Age.	Cases.	Deaths.	Per cent.
Under 1 year of age	[illegible]	[illegible]	[illegible]
From 1 to 5 years of age	[illegible]	[illegible]	[illegible]
From [illegible]	[illegible]	[illegible]	[illegible]
From [illegible]	[illegible]	[illegible]	[illegible]
From [illegible]	[illegible]	[illegible]	[illegible]
Over [illegible]	[illegible]	[illegible]	[illegible]

This table does not support the statement that adults are more likely to be attacked than children, but it must be remembered that it relates to cases occurring in private practice, in a community in which the adults were largely protected by previous attacks, or by passing through repeated epidemics.

In a review of the mortality in the same epidemic, with reference to age, Dr. C. B. White arrives at the following conclusions:

"First. That the mortality of boys at four years is not because a very much larger number of boys were taken sick, but that there is an actual greater mortality.

"Second. It is seen that, though the deaths decline with great rapidity—being at four years, 344; at five years, 169; at six years, 65; the cases do not decrease in the same ratio, but decline as follows: Cases at four years, 822; cases at five years, 740; cases at six years, 624; the recoveries being proportionally much larger.

"Third. From seven to eleven years of age the death-rate remains nearly uniform, the disease being comparatively much less fatal. According to Dowler, the mortality among children in the epidemic of 1841, in New Orleans, was very small. On the other hand, in the epidemic of [illegible], in the same city, it was considerable."

Dr. Charles Delery has given the following table, compiled from the official reports in the office of the Board of Health, showing the mortality during the epidemic of 1867, among children born in the city of New Orleans:

Age.	Males.	Females.	Total.
Under one year	[illegible]	[illegible]	[illegible]
1 to 2 years	[illegible]	[illegible]	[illegible]
2 to 3 years	[illegible]	[illegible]	[illegible]
3 to 4 years	[illegible]	[illegible]	[illegible]
4 to 5 years	[illegible]	[illegible]	[illegible]
5 to 6 years	[illegible]	[illegible]	[illegible]
6 to 7 years	[illegible]	[illegible]	[illegible]
7 to 8 years	[illegible]	[illegible]	[illegible]
8 to 9 years	[illegible]	[illegible]	[illegible]
9 to 10 years	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]

Total deaths from July 29, to November 7, 1867: Males, 167; females, 133 (of these 5 colored, 2 males and 3 females).

Dr. Henry Smith reports that in the epidemic at Shreveport, La., in 1873, out of a total of 584 deaths in which the age was ascertained,

"100 died under 10 years of age.
93 died between 10 and 20 years of age.
156 " " 20 " 30 " " "
134 " " 30 " 40 " " "
59 " " 40 " 50 " " "
29 " " 50 " 60 " " "
13 " above 60 years of age."

IMMUNITY is acquired by suffering an attack of the disease, or by long residence in localities where it is endemic or prevails frequently as an epidemic; this acquired immunity is not, however, absolute.

Second attacks no doubt occasionally occur, although this has been denied by some authors. Blair, whose experience was very great, says that he does not believe there is an instance of a second attack after a month's perfect restoration to health. Other authors are equally positive in their statements. On the other hand, we have numerous authentic accounts of second attacks. Thus "Dr. Jackson states that in Spain, during the epidemic of 1820, twenty well-authenticated instances came within his knowledge, of persons being attacked who had the disease before." Dr. Wragg, speaking of the epidemic in Charleston in 1854, reports the occurrence of second attacks in a number of instances, and says: "Six of these were so well proved as to admit of no doubt on the subject. Some of the patients were identified as having gone through the fever in this (the Roper) hospital in 1852, throwing up black vomit on both occasions" (La Roche). Dr. Rush has given evidence of the same kind, and says that a second attack was more common when the first had been comparatively mild.

Dr. Deléry, in his account of the epidemic of 1867, in the city of New Orleans, gives three cases of second attacks—one fatal, in which the first attack occurred in a previous epidemic in the same city, and was vouched for by experienced physicians known to him. While, then, it cannot be denied that second attacks occasionally occur, the evidence of experienced observers in all parts of the yellow-fever zone is opposed to the view that this is a common occurrence. Those who have considered yellow fever nothing more than a grave form of malarial fever—an idea which was entertained by numerous physicians in this country and in the West Indies in the early part of the present century, very naturally failed to differentiate the disease from the endemic malarial fevers which they encountered, and believed that it might recur an indefinite number of times.

Acclimatization.—It is a remarkable fact that the population of a large city like Havana, or Rio Janeiro, in which yellow fever has been endemic for a series of years, enjoys such a degree of immunity from the effects of the deadly poison that there is no interruption of business or pleasure at a time when strangers in the city are falling sick on every side. The development of an *epidemic* in these cities depends upon the presence of susceptible strangers in sufficient number to furnish a series of cases considered large enough to justify the use of the word. The presence of but few strangers during the epidemic season leads to the announcement that the disease is not epidemic, but that sporadic cases occur from time to time. Under exceptional circumstances, however, epidemics are developed in these endemic foci of the disease, in which those who, by birth or long residence, were supposed to be acclimatized, furnish a certain quota to the general mortality. This has frequently occurred, for example, in the city of New Orleans, where yellow fever formerly prevailed almost annually, and where the *creole* population was supposed to enjoy an hereditary immunity. Dowler, who has made a special study of the question, says of the creole population of New Orleans:

"A few physicians and others, mostly advocates of the contagiousness of yellow fever, maintain that all the creoles of New Orleans, not less than strangers, have this disease once during life, for the most part during childhood, and that it proves fatal to many of them. . . . This sweeping statement, however, is with few exceptions erroneous, as may be proved by authentic documents concerning all of the epidemics witnessed by the writer for seventeen years, not excepting the extraordinary one of 1853 itself.

"It will have been remarked by careful observers that many families have been settled in New Orleans for half a lifetime without ever having had yellow fever. Indeed, it has been thought by many physicians, previous to 1853, that at least one-third of all strangers settling permanently in New Orleans escaped yellow fever altogether. . . .

"The exemption of the creolized of the city is a fact which every epidemic has confirmed; for example, take that of 1841, in which 1,800 died; five of whom only were natives of the city; one aged three weeks; three, two years. In 1843, among 692 deaths from yellow fever, but two are certified as having been born in New Orleans."

The writer quoted believes, with many other physicians residing in endemic foci of the disease, that immunity is, "to a great degree, hereditary, or transmissible from parents to children." This is generally accepted among the physicians and the native population of the city of Havana, but there is reason to believe that it is a mistake, and that the creole child owes his immunity not to his parents, but to individual acclimatization, and not infrequently, to say the least, to a mild, unrecognized attack of yellow fever. Dr. Dowler says "that many creole children had, during the epidemic of 1853, a fever—a slight fever—yellow fever if you please—known as such rather by the co-existence of the epidemic than from any severe symptoms among these children—a slight fever never yet described, having generally but one paroxysm, lasting from six hours to one, two, or three days, scarcely ever requiring medication. That a few of these cases acquired an alarming violence, and even proved fatal, is most true—most deplorable."

Hinemann writes with reference to Vera Cruz: "Until lately the physicians and people of Vera Cruz supported with fanaticism the dogma that natives were absolutely exempt from yellow fever. But the fearful epidemics of recent years (1875, 1877, 1878) have worked a change; for so many native children and adults suffered, that the truth could no longer be denied that these do not enjoy an absolute immunity."

In Cuba, the dogma that creoles are exempt from yellow fever, did not withstand the searching investigation made by the Havana Yellow Fever Commission of 1879. We quote some of the evidence collected and reported by Dr. Chaillé, President of this Commission. "Dr. Navea, of San José de las Lajas, an inland town some twenty miles southeast of Havana, presented the following interesting report after it had received the full approval of Drs. Cabrera and Bofil, his colleagues at San José: 'We have here annually, in the practice of the three physicians, from 20 to 30 Cuban children, and from 30 to 40 Cuban adults, attacked with bilious remittent fever which is popularly designated typhus. There is nothing whatever to constitute a differential diagnosis between this fever of the natives and the yellow fever of strangers. It is characterized by its hæmorrhagic tendency, albuminuria, black vomit, and all the symptoms of yellow fever. It is so well marked that, even when seen by the uneducated they exclaim "Vomito." The treatment for the one is best for the other. We have never seen a second attack of this bilious remittent fever, nor one who had recovered from it attacked with yellow fever. If anyone of us three physicians here sees this fever attack a native Cuban, we say, "bilious remittent fever," and if it attacks a person not a native of Cuba we say "yellow fever;" but at bottom it is the same disease; and we agree to call it bilious remittent fever in Cubans, solely because these believe themselves exempt from yellow fever, and are so prejudiced that they would be [illegible] (I assumed these [illegible] [illegible] [illegible] yellow fever.

"Dr. Mackintosh, of [illegible], reported as follows: 'During [illegible] 18[illegible], the sanitary condition [illegible] good, but a remittent fever has prevailed among children, which, however, had a typhoid, although it resembles in severity the fevers to which Europeans give this name, and which no other infective cause. By the [illegible] I have had one patient which must [illegible] any [illegible] in the town. It presented all the symptoms of yellow fever, for, on the second day, this patient had the characteristic vomit and [illegible], and died on the third day. In a consultation with three other physicians, they agreed with me in my diagnosis, with this difference, that they said that these same symptoms, which constituted yellow fever in strangers, constituted in natives typhoid. I have never had the right to see children born [illegible] of this disease.'

"Dr. [illegible], a graduate of Paris, who has had [illegible] some experience in [illegible], writes as follows: 'In my own practice I have seen cases of yellow fever in children from one to five years of age, and [illegible] but very few of age, by whom it has been [illegible], and I am well convinced that children born in [illegible] are exempt in the same conditions [illegible] first years of their lives as are other new-comers, and [illegible] liable to be attacked. Nevertheless, I consider that children are generally less prone to suffer severely.' [illegible] Worthy practitioners of this locality give the name of typhus fever to these cases, and [illegible] they admit that no difference whatever exists between the symptoms, course, and duration of this [illegible] with yellow fever, still they think the former a [illegible] fever, and [illegible] more amenable to [illegible]."

Blair, who has written a classical account of the epidemic of 1837–41 in British Guiana, says that "infancy was one of the most [illegible] causes of the action of the yellow fever poison. The constitution of the new born or young white creole was highly susceptible. [illegible] to the category of new-comers."

Recent experience at Key West (epidemic of 1887) shows that the children of [illegible] Cubans, born since the arrival of their parents at Key West, have the same susceptibility to the disease as other [illegible] born of unacclimated parents. We cannot, therefore, admit that inherited immunity has been established.

On the other hand, we are not prepared to assert that there is no immunity independent of an attack of the disease. Unrecognized mild attacks in adults, and especially in the young and among newly-born children, are no doubt of frequent occurrence. But it cannot be claimed that, independently of any febrile manifestation, individuals of all ages, who have resided in an infected locality for some time, acquire a comparative immunity, which increases with length of residence and degree of exposure to the action of the specific cause of the disease.

It is generally conceded that this acclimatization is lost, or at least, reduced to a considerable extent, by residence for some years in a latitude outside of the "yellow fever zone." And some authors maintain that the immunity due to an attack of the disease is in like manner lost, or is [illegible] by [illegible] absence from its accustomed haunts. The writer's observations are opposed to the latter statement. In the epidemic at Fort Barrancas, Fla., in 1875, in which nearly every unprotected person who remained in the infected area suffered an attack, three officers, who had previously had yellow fever, remained in perfect health, although they had all resided for several years in a northern locality since the date of their attack—one for more than twenty years.

[illegible], who has had an extended experience at Vera Cruz, says that "even foreigners may remain immune to the disease for a considerable number of years, provided they do not leave the focus of the disease during that period. An absence of a few months only is sufficient to take away this immunity."

That foreigners may remain for years in Havana, in Rio Janeiro, or other endemic foci of the disease without suffering an attack is undeniable. I found this especially to be the case in Rio, where there is a large foreign population. It is true that some who have escaped for a series of years often fall sick at last in a season of unusual epidemic prevalence, but comparative immunity is shown by the fact that, as among the creole population, the disease is not so fatal with them as among newly arrived strangers. The effects of acclimatization in large cities like Rio Janeiro and Havana are illustrated by the fact that in these cities yellow fever is, for the native population, a disease of minor importance. This is shown by the following tables.

In Rio, a city having a population of 400,000, the mortality from some of the principal causes of death is given in the official report of the Superior Board of Health as follows for the year 1886, which was considered an epidemic year so far as yellow fever is concerned:

		Deaths.
1.	Tuberculosis	[illegible]
2.	Diseases of the respiratory organs	[illegible]
3.	Diseases of [illegible]	[illegible]
4.	Diseases of the digestive system	[illegible]
5.	Infectious diseases	[illegible]
6.	Yellow fever	[illegible]

In Havana, the principal causes of death among the civil population, in the year 1886 are given officially as follows:

		Whites.	Colored.
1.	Phthisis pulmonalis	[illegible]	[illegible]
2.	Enteritis [illegible]	[illegible]	[illegible]
3.	Yellow fever	[illegible]	[illegible]

That acclimatization is not due to the influence of climate, but is an acquired tolerance to the action of the yellow fever poison, is shown by the history of this disease in Rio Janeiro. At the time of its introduction, in 1849, it found an unprotected population, and for a series of years prevailed as an epidemic among this population, causing a mortality quite comparable to that in similarly situated cities in other parts of the world when first invaded by the scourge. At present the native population furnishes but a comparatively small proportion of the total number of deaths by this disease.

PREDISPOSING CAUSES.—*Plethora* is considered by some physicians, in the regions where yellow fever prevails, to be a predisposing cause, and to account for the greater susceptibility of strangers from northern latitudes. *Constipation* is generally regarded as an unfavorable condition. Other predisposing causes are, *fatigue* from excessive exertion, *debility* resulting from a recent debauch, or from any other cause, *exposure* to the direct rays of the sun, violent mental emotions, such as *grief* or *fear*; and, in general, any influence capable of depressing the vital powers, or any disturbance of the normal functional activities of the body.

MODE OF INFECTION.—Yellow fever is contracted by exposure in infected localities, and not directly by contact with the sick. This is established by a mass of evidence which is recorded in the literature of the subject, but is still denied by some physicians, who regard it as a contagious disease in the same sense that small-pox and measles are contagious. In this respect it is like cholera and typhoid fever. There is something given off from the body of the sick by which, when external conditions are favorable, new centres of infection are established; and it seems probable that, as in the diseases mentioned, this germinal principle of the disease is contained in the alvine discharges of the sick. That it is not given off from the general surface of the body is an inference which we base upon the established fact that the disease is not transmitted directly from individual to individual. It is true that the contagionists bring forward a mass of facts which, regarded alone, seem to give some support to their views, but we believe these facts to be explicable in accordance with the statement above made. Persons who successively fall sick in the same house, or on board ship, are not infected one from another, but contract the disease from a common source, the infected premises, or ship. Indirectly, of course, they contract the disease through the agency of the individual or families through whom the house or ship first became infected.

Formerly the battle between the contagionists and the non-contagionists was one involving the question of local origin on one side, together with a strenuous denial of the transmissibility of the disease and the value of quarantine restrictions. The contagionists, on the other hand, insisted upon the exotic origin of the disease and its transmissibility by ships and persons. And to this extent they were right. There can be no doubt that the prevalence of the disease in the United States depends upon the introduction of an exotic germ; but it also depends upon local conditions which favor the development of this germ. The yellow fever patient, however many germs he may carry in his intestine or elsewhere, does not directly endanger those who come near him, any more than a gelatine culture of the spirillum of Asiatic cholera or of the anthrax bacillus places in danger the student of bacteriology who is engaged in studying it.

It is well known to the people of the City of Mexico that a visit to the sea-coast city of Vera Cruz during the epidemic season is likely to result in an attack of yellow fever. It is also well established that those who fall sick with the disease after their return to the City of Mexico never communicate it to others who are closely associated with them as attendants, etc. The same is true at the health-resort Petropolis, located in the mountains within a few hours' ride of the city of Rio Janeiro. Frequently individuals fall sick in Petropolis who have visited the infected city of Rio. Never do they communicate the disease to others. This is also the experience of the physicians in charge of hospitals—*e.g.*, the Charity Hospital of New Orleans; so long as the hospital and its vicinity remain uninfected cases do not originate in the hospital, although yellow fever patients may be admitted to the wards with unacclimatized persons suffering with other diseases, and be cared for by susceptible attendants.

In his report upon the camps established near Memphis in the epidemics of 1878 and 1879, Colonel Cameron makes the following statement: "It was found necessary that the officer in authority should set an example of constant indifference to attack in order to appease, as far as possible, the constant anxiety of the population under his charge. Especially was this true in 1878, as depopulation went on slowly that year, and infected people poured daily into the camps from the more pestilential portions of the city. Very many reached camp with the fever on them, so that as many as seventeen persons fell victims in one night, not a few in their tents. *In no instance, however, did they communicate the disease to their families or bed-fellows*, as far as could be traced."

In the same epidemic (1878) Dr. Minor reports that over thirty cases were discovered among refugees in Cincinnati, O., and says: "No physician or nurse contracted the disease, and in no instance did it exhibit any tendency to spread." The same was true in Nashville, the same year; twenty imported cases occurred in different parts of the city without any local cases resulting from them (Report of Nashville Board of Health). Evidence of this kind could be extended to fill a volume, but sufficient has been presented to establish the statement made, and the reader may be referred to the "Proofs of Non-contagion" in the second volume of the classical work of La Roche (pages 236–566).

We have already, in discussing the nature of the specific cause of the disease, referred to the fact that there is no satisfactory evidence that the disease is contracted by the use of contaminated water, as is the case in cholera and typhoid fever. We quote the following conclusions of the Board of Experts appointed to investigate the epidemic of 1878:

(6) "Yellow fever is a disease of singular local attachments. It often becomes epidemic in one section of a city, and sometimes a very small section of it, while it fails to present itself at all in other sections of the same city, and in these localizations it exhibits a remarkable indifference to topographical and social surroundings."

(7) "In the dissemination of yellow fever, atmospheric air is the usual medium through which the infection is received into the human system."

ETIOLOGY OF EPIDEMICS.—The development of an epidemic of yellow fever, in places removed from the endemic foci of the disease, depends upon: (*a*) the introduction of the specific cause by yellow fever patients, or through infected articles—fomites; (*b*) local conditions which favor the multiplication of the specific germ external to the body; (*c*) favorable meteorological conditions; (*d*) the presence of susceptible individuals in the infected locality.

We quite agree with the Board of Experts above quoted in the following conclusion also: (31) "The most frequent agency in the dissemination of yellow fever from place to place is found in yellow fever patients; and more epidemics of yellow fever have resulted from the introduction into previously exempt places of persons sick of the disease, or falling sick after arrival, than from all other causes. To what extent the body of the sick person is responsible for this result, and to what extent his clothing and baggage is responsible for it, is not known."

The last clause in the above-quoted conclusion shows that the Board of Experts admitted the possibility that the yellow fever patient acts simply as a carrier of the infectious agent, about his person or in his baggage. The fact that he has yellow fever is evidence that he comes from an infected locality, and he may be instrumental in establishing a new centre of infection for this reason, rather than because he is himself a victim to the disease. This is a possibility which should not be lost sight of; but, reasoning from analogy and from known facts, it seems extremely probable—indeed we may almost say certain—that the sick establish new centres of infection because the infectious agent is reproduced in their bodies and is contained in their excreta.

That infected centres may be established independently of the arrival of sick persons is, however, beyond question. A striking instance of this is afforded by an outbreak which occurred in Madrid in 1878. A circumscribed epidemic was developed in this city about the first of September, which resulted in a mortality of thirty-five out of fifty cases taken sick. This outbreak was traced to importation, although all of the cases occurred among the permanent residents of the infected area. Associated with the young people who first fell sick, crowded in the same rooms with them to the number of ten or fifteen in a room, were a number of soldiers recently returned from Cuba, *with their baggage*. These men had themselves suffered from yellow fever in Cuba, or were acclimatized by long residence there.

We have on record instances which appear to be authentic, of the development of an epidemic as a result of the opening of a trunk containing *infected clothing*, sent from a locality where the disease was prevailing to one previously healthy. Epidemics have also been traced to the unloading of earth *ballast* from the shores of an infected port upon the wharves of a healthy place in the yellow fever zone.

The first cases of local origin in an epidemic do not, as a rule, occur until some time has elapsed after the arrival of the infected ship, or fomites, or sick person responsible for the introduction of the "germ." This interval may vary from a few days to several weeks, according as local conditions are favorable or otherwise for the development of the infectious agent.

In the great epidemic of 1878, which was traced by Dr. Choppin, President of the Louisiana State Board of Health, to importation by the steamship Emily B. Souder, which arrived from Havana on the 23d of May, the first cases of local origin did not occur until after an interval of five or six weeks. But these first cases occurred, according to Dr. Choppin, in the immediate vicinity of the houses in which two of the officers of the Souder (Clarke, the purser, and Elliott, one of the engineers) died soon after the arrival of that vessel.

The *local conditions* which favor the development of the exotic germ are various: (a) *Latitude*. Our account of the geographical limits of the prevalence of the disease suffices to show the influence of latitude, which appears to be simply a question of temperature. (b) *Alti-*

ease. The facts do not justify the conclusion that the limitation as to altitude depend solely upon the lower temperature of elevated regions. As pointed out by Hirsch, "the disease occurs about as rarely points in the West Indies where the climate is still in the highest degree tropical. On the other hand, there have been epidemics in cool weather or from considerable altitudes, as, for example, at Newcastle in Jamaica," (elevation about 4,000 feet). In the Antilles the disease has rarely appeared at a height of more than 700 feet. In Mexico it has prevailed at Cordova (2,800 feet), but is unknown in the cities of Orizaba, Jalapa, and Puebla, which have an elevation of more than 4,000 feet. In Spain a single limited outbreak has occurred at Madrid, which is about 2,000 feet above the sea-level; but with this exception the altitudinal range has rarely exceeded 1,000 feet. In the United States the most elevated locality in which the disease has prevailed as an epidemic is Chattanooga, Tenn., which is 745 feet above the sea-level. (c) Yellow fever is essentially a disease of the seacoast, and while in great epidemics it may become widely diffused in the interior it follows for the most part the routes of commercial travel. (d) It is a disease of towns and towns of considerable size, and rarely extends to small country villages or among the scattered rural population. (e) In seaport towns it frequently makes its first appearance in the vicinity of the wharves, or in localities frequented by sailors. (f) Above all, it is a disease which is influenced by local sanitary conditions. In those places where it is endemic it haunts the low-lying and filthy portions of the towns, and in epidemics it exhibits a marked preference for towns which are in an unsanitary condition. It frequently happens that when a town is invaded the disease is limited, for a considerable time at least, to the filthy portions of the place, in which the degraded victims of poverty and vice congregate in ill-ventilated apartments surrounded by the filth which accumulates in such localities when not kept under a rigid sanitary supervision. (g) Decomposing organic matter of animal origin seems to furnish an especially favorable nidus for the germ. This is shown by its favorite haunts, and by the fact that in marshy places, in the vicinity of rivers, where malaria prevails and where vegetable decomposition is active, it does not effect a lodgment. On the other hand, the influence of putrefying organic matter of animal origin in the production of epidemics has several times been made apparent. Dr. Parkes the famous English hygienist maintained the fæcal origin of the disease, and there seems to be good reason for the belief that the accumulation of this kind of filth in exposed situations is favorable to the development of an epidemic. Conditions relating to soil and geological formation have not been shown to influence in an essential manner the development or diffusion of the disease. On the other hand, the numerous epidemics which have occurred on shipboard show that the disease is quite independent of such conditions, and at the same time disprove the theory, so vigorously maintained by numerous authors during the first half of the present century, that the disease is due to emanations of the same nature as those which produce the so-called "malarial fevers." Meteorological conditions exercise a most decided influence upon the prevalence of the disease in localities where it is endemic, and its epidemic extension when new infected centres are established among a susceptible population. The influence of temperature is shown by the fact that it is a disease of the tropics and of hot seasons; that it prevails throughout the year in the cities of Rio Janeiro, Havana, and Vera Cruz, although to a much less extent during the cool season; while in more temperate regions its prevalence is limited to the summer season. It does not prevail as an endemic disease in places which have a mean winter temperature much below 68°, and as a rule epidemics are not developed at a lower temperature than 72° to 75° Fahr. The approach of cool weather checks the progress of an epidemic, and it terminates completely when the temperature falls to the freezing point. There are, however, numerous facts which indicate that the infectious agent is not destroyed by a freezing temperature, although rendered inactive. Epidemics which have been checked by frost have been revived by the recurrence of warm weather, and in certain instances in temperate regions the germ has survived the winter, and a second epidemic has occurred without a new importation (Memphis, 1878-9; Cadiz, 1800-1; Malaga, 1803-4). Epidemics which originate early in the season often terminate before there is frost, simply because the susceptible material is exhausted; but when strangers venture within the infected area they furnish evidence of the continued activity of the infectious agent, by falling victims to the disease. The influence of season is shown by the following tables:

Mortality from Yellow Fever in Rio Janeiro during the Year 1886.

Month.	Total deaths.	Mean temp.	Rain-fall.
January	143	77.6	7.40
February	298	79.0	10.64
March	503	77.8	9.08
April	344	75.90	8.81
May	17	69.9	3.06
June	58	67.90	1.08
July	9	66.97	1.55
August	2	67.86	5.27
September	1	68.81	4.39
October	1	69.62	1.97
November	1	73.57	1.17
December	1	74.95	5.42
Total	1,449		[illegible]

Mortality from Yellow Fever in Rio Janeiro from January, 1851, to July, 1870 (Hirsch).

Warmer season.		Cooler season.	
January	1,118	July	212
February	1,766	August	164
March	1,722	September	148
April	1,384	October	173
May	596	November	146
June	501	December	122
Total	7,087 = 88 per cent.	Total	965 = 12 per cent.

Mortality from Yellow Fever in the City of Havana for ten years—1870 to 1879, inclusive.—(Chaillé: Report to National Board of Health).

Month.	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	Average for ten years.
January	6	58	20	42	7	16	24	8	26	11	17
February	1	22	11	26	3	9	23	7	19	13	13
March	1	72	4	27	18	12	29	11	4	4	18
April	6	54	3	67	22	31	32	8	26	11	26
May	14	91	11	237	95	42	108	16	36	40	69
June	46	287	66	376	175	184	296	110	151	211	190
July	112	289	68	416	301	187	622	440	448	477	336
August	207	158	70	317	319	141	536	426	352	315	282
September	51	75	50	145	180	146	275	264	175	148	150
October	17	44	28	55	91	109	42	150	86	11	63
November	6	11	12	9	32	132	27	28	26	11	29
December	10	11	70	9	21	58	39	73	12	9	30
Total	666	991	415	1,586	1,426	1,012	1,619	1,374	1,559	1,445	

These above tables show us that temperature is only one of several factors which control the prevalence of the disease, for with a tolerably uniform temperature during a series of years at Vera Cruz for example, we have some years marked by a very considerable mortality—e.g., 1875, 1881—and others in which but few cases occur, even during the hottest part of the season—e.g., 1869, 1870, 1879. Again it happens that after a summer of almost complete exemption an epidemic is developed in the autumn which runs through the entire winter (1880-81; see p. 41). An important factor, which does not usually appear in statistical tables, relates to the number of susceptible individuals present at different times. The arrival, for example, of contingents or of bodies of unacclimated troops at Havana or Vera Cruz would almost inevitably be followed by a marked increase in the mortality from yellow fever

Although the development of an epidemic seems to require a comparatively high temperature (75° to 80°), experience shows that it may continue in full force at a much lower temperature (60° to 70°), when local conditions are favorable and a susceptible population is exposed in the infected area. A good example of this is given by the epidemic at Chattanooga, Tenn., which city was invaded for the first time in 1878. We obtain our data from a paper by Dr. J. H. Vandeman.

The first imported case, a refugee, was taken sick August 17th; died August 21st. The first case among the residents of the city occurred over three weeks later (September 13th), and proved fatal on September 19th. The further progress of the epidemic, and the mean temperature for each week, are shown in the following table:

Epidemic at Chattanooga, Tenn., in 1878.

Week ending.	New cases.	Deaths.	Mean temperature.
September 27th	40	21	79.71°
October 4th	47	19	70.42°
October 11th	144	22	66.66°
October 18th	99	33	63.14°
October 25th	74	21	56.52°
November 1st	30	12	48.66°
November 8th	9	4	53.04°
November 15th	2	2	51.83°

Here we have an epidemic which was at its acme when the temperature was below the mean temperature of the winter months in Rio Janeiro, Havana, or Vera Cruz. The monthly mean temperature in the last-named city, and the mortality for each month, for a period of four years, are given in the following table:

Month.	1878.		1879.		1880.		1881.	
	Deaths.	Mean temp.	Deaths.	Mean temp.	Deaths.	Mean temp.	Deaths.	Mean temp.
January	16	69.5°	6	72.9°	2	73.2°	28	67.3°
February	5	72°	4	72.8°	0	75.3°	22	67.4°
March	0	76°	2	78.9°	1	78.1°	29	75.4°
April	1	80.5°	1	79°	1	80.8°	29	77.1°
May	7	84.3°	1	83.4°	0	84.9°	94	82.5°
June	58	86.9°	1	83.5°	0	86.4°	233	84.6°
July	114	85.6°	2	85.6°	1	87.6°	132	88.1°
August	110	84.6°	1	86.5°	3	86.2°	39	87.6°
September	62	83.4°	3	80.7°	9	83.3°	22	84.3°
October	45	81.2°	0	79°	42	77.5°	25	80.6°
November	24	77.3°	0	79°	92	76.7°	18	75.3°
December	7	70.2°	0	73.4°	98	74.7°	4	73.6°

An inspection of the above table shows that after an epidemic in the summer of 1878, which may be said to have lasted from June to December, two seasons of comparative immunity followed, which cannot be ascribed to a lower temperature. Indeed, the average temperature for the six months from April to September, inclusive, was somewhat greater in 1880 than in the epidemic year 1878. Again we see that in 1880, after an unusually healthy summer, yellow fever prevailed to a considerable extent during the months of October, November, and December, although the temperature was less than during the corresponding months of the preceding year. The epidemic impetus continued during the following year, attaining its maximum of intensity in the months of May, June, and July, although in two of these months (May and June) the temperature was lower than in the corresponding months of the preceding healthy summer.

Another factor of importance in the etiology of yellow-fever epidemics is atmospheric *moisture* and *precipitation*. Yellow fever is a disease of the sea-coast, and of the margins of great rivers, and it does not prevail in arid, desert places in the interior, although the elevation may be but little above the sea-level, and the temperature extremely high. There is reason to think that this difference is largely due to the difference as to moisture in the atmosphere and in the soil. Some authors have insisted especially upon the presence of moisture in the atmosphere almost to the point of saturation, as an essential condition for the development of an epidemic. But, on the other hand, epidemics have sometimes occurred in unusually dry seasons, as at New Orleans in 1841. In Martinique, according to Dutrouleau, yellow fever has sometimes committed its greatest ravages after and during the dryest season.

La Roche states that the epidemics in Philadelphia were "connected in most instances, at least, with a deficiency of atmospheric and terrestrial humidity—though in all instances of its occurrence it will be found that, prior to the accession of dry weather, the earth had been more or less saturated with rain." As pointed out by this author, "the coexistence of a clear atmosphere is often seen." The fact seems to be that, while a certain amount of moisture is essential, the limits vary considerably. In general, it may perhaps safely be said, that the degree of humidity and the temperature most favorable for the rapid decomposition of organic material, which forms the nidus in which the infectious agent multiplies, is the most favorable for the epidemic extension of the disease.

Heavy rains, by purifying the air and cleansing the streets and sewers of an infected city, exercise a favorable effect upon its sanitary condition, and in the tropics the commencement of the rainy season often puts an end to the prevailing epidemic. It is probable that the statement made by some authors, that upon the coast of Guiana, and elsewhere in the tropics, dry weather is favorable to the spread of the disease, is but another way of stating the fact that the heavy rains of tropical regions are unfavorable, the dry weather being only dry by comparison.

In the north temperate zone southerly *winds* are favorable to the progress of an epidemic, because of the elevated temperature which accompanies them, and, on the contrary, northerly winds have a tendency to arrest it. Fresh sea-breezes, and especially the trade-winds in the tropics, by reason of their constancy, are beneficial from a sanitary point of view. They dilute and carry away the poisonous emanations from the foul and narrow streets of infected cities, and refresh and invigorate the population.

There is no evidence that the infectious agent of yellow fever can be conveyed by the wind, in an active condition, to any considerable distance, and the wind has but little to do with the dissemination of the disease. In cities, the extension of an epidemic from centres, resulting from the importation of cases, or fomites, is usually quite gradual and independent of the prevailing currents of air. The Board of Experts appointed by Congress to investigate the epidemic of 1878 arrived at the following conclusion:

"We know of no instance, either from our own observations or from the published records of yellow fever, in which it has been established that the disease has been carried to any considerable distance by atmospheric currents, or by any modes or vehicles of conveyance other than those connected with human traffic and travel."

In the comparatively small and land-locked harbor of Havana, vessels which anchor some distance from shore, and which are kept in a good sanitary condition, do not suffer from yellow fever, unless unacclimatized members of the crew are permitted to go on shore. Vessels lying at the wharves, on the contrary, are very likely to become infected.

There are, however, numerous instances in which vessels have become infected from the shore, or from other vessels, or in which yellow fever has appeared in places lying to the leeward of infected vessels, in which the transmission of the disease has been ascribed to the agency of the wind. It is difficult to decide to what extent this explanation is correct, for we would have to be sure that no direct communication had occurred before accepting it; and the possibility that the infection may be conveyed to the shore by infected articles thrown overboard, in the case of infected vessels anchored to the windward of healthy places, must be borne in mind.

PROPHYLAXIS.—What has been said as to the etiology of yellow fever indicates clearly enough the measures of prophylaxis to be relied on in localities subject to invasion. These are: (a) Exclusion of the contagium of the disease by the sanitary supervision, at the port of departure, of ships sailing from infected ports, and their thorough disinfection at the port of arrival, when there is evidence, or a reasonable suspicion, that they are infected; (b) the establishment of quarantine stations, and, so far as practicable, in sparsely-inhabited places; (c) the disinfection of vessels, and of the clothing and bedding used by the sick, and of localities into which cases have been introduced, or which have become infected in any way; (d) depopulation of infected "localities," the removal of all susceptible persons whose presence is not absolutely necessary for the care of the sick.

The rigid quarantines of former days, which proposed to exclude the disease by detaining ships and passengers at a quarantine station for a fixed period of time after their arrival, irrespective of the sanitary conditions, and if yellow fever occurred on board, to quarantine the vessel for a further number of days after the occurrence of the last case, has been found unreliable, and has been generally abandoned. The modern method of exclusion, which relies upon the sanitary supervision of the ship at the port of departure, and, as far as practicable, while in transit, and upon isolation of the sick and disinfection of the vessel, when cases of yellow fever have occurred on board, at a quarantine station provided with the appliances for doing this in an effective manner, has proved far more successful. Reliance upon a time quarantine is unsafe, for the reason that the vessel may remain infected for an indefinite period of time after the occurrence of cases on board, or even independently of any case, if she has been at the wharves of an infected port. No more cases occur after all of the passengers and crew, susceptible to the disease, have suffered an attack, and it may happen that there are no susceptible persons on board; but the vessel is none the less infected and dangerous to the inhabitants of the port which admits her to pratique without a thorough disinfection. On the other hand, if we are to trust to the measures indicated, the sooner they are put into execution the better.

Depopulation of infected ports or towns, when yellow fever makes its appearance during the epidemic season, is a measure of great importance, which should be carried out, when practicable, under proper medical supervision. It has often happened, especially upon naval vessels, that the well are retained upon the infected ship, and the sick sent to a hospital on shore, under the idea that the chief danger lies in contact with the sick. This is a serious mistake, and has resulted in the loss of many lives. In the United States Army it is well understood that all susceptible well persons are to be removed to a locality actually as soon as yellow fever is known to have attacked an individual in quarters occupied by troops. It has been found by experience that a move into camp checks the progress of the disease among the garrison, although this may be established but a few miles from the infected barracks.

In the case of towns in a secondary position as to invasion by the disease, depopulation often occurs in a way which is most disastrous to other communities. It very often happens that the nature of the disease is not at first recognized by the physicians; and when recognized the hope is entertained that it will not become epidemic, until a considerable mortality, or the death of some prominent citizen, arouses the fears of the people and a general "stampede" occurs. The attempt has often been made to restrain the people of an infected town by means of a "sanitary cordon," composed of armed guards. This procedure is not only inhumane, so far as the susceptible inhabitants of the place are concerned, whom it is proposed to compel to remain within the infected area, but it is as a rule futile; for when a frightened man desires to escape from an unseen enemy, it is difficult to keep him in a place not surrounded by insurmountable walls, or by an impassable barrier of some kind.

At the International Sanitary Conference at Rome (1885), the following resolution was adopted, with a single dissenting voice—that of the delegate from Turkey:

"6. Land quarantines and sanitary cordons are useless."

This related, it is true, to cholera; but it applies as well to the case of yellow fever. Another resolution, adopted at the same conference, is to this effect:

"8a. The measures recommended against cholera are, in general, applicable to yellow fever and to other diseases which prevail in epidemic form, under the influence of bad sanitary conditions, and which are transmitted by human intercourse.

"The most effective measures for preventing the propagation of diseases of this class are:

"The sanitary improvement of cities and of vessels sailing from infected ports, isolation of the sick, and disinfection of infected or suspected articles and localities."

In yellow fever we require, in addition to this, depopulation of the infected localities, whenever it is practicable, and this should be effected systematically, and with due precautions to prevent the transportation of infectious material to other places.

Of all measures of prophylaxis those which relate to the sanitary improvement of cities and towns liable to become infected are perhaps the most important. Municipal hygiene has made great strides since the early part of the present century, and it is probable, to this fact more than to any other, that certain northern cities which formerly suffered severely from yellow-fever epidemics, owe their long immunity from such visitations—e.g., New York and Philadelphia.

Individual prophylaxis requires the individual, first of all, to avoid infected localities. If it is absolutely necessary for a susceptible person to visit a place where yellow fever is prevailing, or to remain in one in which it has effected a lodgement, he should observe the following precautions: Keep away from low-lying and filthy portions of the city; avoid the vicinity of the wharves, and all localities known to be centres of infection, especially at night; sleep as far from the ground as possible; avoid excesses of all kinds, and especially in the use of alcoholic drinks; keep out of the sun during the hottest part of the day, and be careful not to become overheated by violent exercise; avoid constipation.

With reference to the method of prophylaxis by inoculation, practised in Brazil by Dr. Domingos Freire and in Mexico by Dr. Carmona y Valle, the writer, after a careful examination, has reported officially that:

"There is no satisfactory evidence that the method of inoculation practised by Dr. Domingos Freire has any prophylactic value."

"The claims of Dr. Carmona y Valle, of Mexico, to have discovered the specific cause of yellow fever have likewise no substantial basis; and he has failed to demonstrate the protective value of his proposed method of prophylaxis."

THE PERIOD OF INCUBATION in yellow fever does not usually exceed four or five days, and may be less than twenty-four hours. Instances of a much longer period of incubation have been given by various authors—some as long as six weeks or two months—but we are satisfied that these are due either to error in diagnosis or to the fact that the cases result from the establishment of a new and unrecognized source of infection. Those who believe that the disease is only communicated by personal contagion naturally date the exposure to the latest date when such personal contact was possible. Thus, when a first case occurs on a ship at sea two or three weeks after leaving an infected port, the period of incubation is supposed to be at least this long. On the contrary, the attack is due, in all probability, to the fact that the ship is infected, and the first case will probably be quickly followed by others which have no direct connection with it, but result, as it did, from exposure on the infected vessel. Instances of an attack occurring within twenty-four hours after arrival in a city where the disease was prevailing as an epidemic, are numerous and well authenticated. Dr. Rush says, in his account of the epidemic of 1793: "The seeds of the disease, when received into the body, were generally excited into action in a few days. I met with several cases in which they acted so as to produce a fever on the same day on which they were received into the system." During the epidemic at Gibraltar, in 1804, strangers were in several instances attacked on the second or third day after landing, and some are said to have been seized on the first day. According to Drs. Pariset, Balby, and François, the period of incubation at Barcelona, in 1821, appeared very short. "We have," they say, "very strong reasons to suspect, and these reasons are founded on facts, that this period does not exceed twenty-four hours, or three days at most" (La Roche).

In the epidemic at Fort Barrancas, Fla., in 1875, the writer had an opportunity to fix the limits of the period of incubation. The whole garrison was exposed in the infected locality, and a number of cases had occurred, when the command was removed into camp in a healthy place across the bay—near Fort Pickens. On the day following the removal seven cases were sent back from the camp for treatment in hospital. The next day eleven cases came from the camp; the following day, two, and the fifth day, two. The remnant, consisting of forty-eight individuals, remained in good health until a month later, when two cases again occurred in camp. We do not believe that these two cases represent a prolonged period of incubation, but suppose that in the interval the camp had also become infected.

It is proper to state that several authors, who have had great experience, believe that the period of incubation may be extended to fourteen, or even more days—Blair, Rush, Féraud.

Clinical History.—As a rule, an attack of yellow fever is not preceded by any well-marked *premonitory symptoms*. The attack may occur at night in one who went to bed in his usual state of health, or in the early morning after an uninterrupted sleep, or during the day while engaged in ordinary occupations. In other cases there is a feeling of lassitude and discomfort for two or three days prior to the attack, with loss of appetite, slight pain in the back and loins, a feeling of giddiness or slight headache, flatulent eructations, constipation, a tendency to perspire at night, or upon very slight exertion, and more or less muscular debility, together with a disinclination for any mental exertion.

Dr. Wragg, who had charge of the Roper Hospital at Charleston, during the epidemic of 1854, made particular inquiries with reference to premonitory symptoms, and states that "out of a total of 225 cases the attack was sudden in 92; in 32 it came on insidiously, the patient complaining of malaise, etc., for a considerable time; and that 101 offered the usual symptoms characterizing the approach of fever."

The attack is commonly inaugurated with a more or less decided *chill*, which by its violence and duration affords some indication of the probable severity of the case. In certain grave forms of the disease, however, the onset is insidious, and is not marked by any perceptible chill. In a considerable proportion of the mild cases, also, especially in the tropics, there is no rigor, and the patient experiences, at most, only a slight sensation of coldness, which quickly gives place to that of heat. If a thermometer is placed in the axilla during the initial chill it will be found that the temperature is already considerably above the normal, and very frequently it reaches the highest point attained during the entire attack within a few hours from its inception.

Accompanying the chill are other nervous phenomena, similar in kind to those attending the onset of other specific febrile diseases. There is *cephalalgia*, often very severe, and located by preference in the forehead and supra-orbital region; the eyeballs also are painful, and there is intolerance of light in some instances. *Pain in the loins* is a very constant and early symptom, which occasions much distress, and sometimes extorts groans and cries from the patient. At the same time pain is usually experienced in the lower extremities, often of a very severe character, constituting the *coup de barre* of the French authors; it affects especially the calves of the legs, the knees, and the ankles. These symptoms continue, and are even aggravated, after the rigor has passed and the febrile stage is fully developed; in the meantime, the *face* becomes flushed, and sometimes deep-red and swollen in appearance; the *eyes* are shining and suffused, the conjunctivæ more or less hyperæmic and often deeply injected, in severe cases presenting a fiery, inflamed appearance which is accompanied by photophobia; the *skin* becomes hot and dry, and there is apt to be, especially in patients of a nervous temperament, great *restlessness* and *jactitation*.

Systematic authors have described numerous varieties of the disease, but these are for the most part simply different grades in the degree of severity, or depend upon individual peculiarities and complications. Yellow fever is the same in all parts of the world where it occurs, and every great epidemic furnishes examples of the several varieties which have been described. It will suffice here to mention the classification adopted by one or two standard authors. La Roche gives an account of the clinical history of the disease under the following headings: Inflammatory species, including three grades, intense, mild, and ephemeral; congestive species, including four grades, aggravated, adynamic, walking, and apoplectic. Bérenger-Féraud, in his elaborate account of the disease as it prevails at Martinique, classifies the cases as follows:

1st Degree.—Mild yellow fever.

2d Degree.—Yellow fellow of moderate intensity; A, cases in which the onset is frank; B, cases in which it is insidious.

3d Degree.—Grave yellow fever; A, ordinary forms, including the gastric, adynamic, ataxic, congestive, and typhoid forms; B, rare forms, including the hyperæsthetic, gangrenous, algid or choleraic, and hydrophobic.

4th Degree.—Yellow fever *sidérante*.

Different epidemics are sometimes characterized by the predominance of one or the other of the forms described, and the character of the disease, as to severity, often varies greatly during the same epidemic. The earlier cases are sometimes mild and the mortality small, while later the greater intensity or malignancy of the poison is shown by the occurrence of a large number of cases of the severest grade, and even of those rapidly fatal attacks denominated by the French *sidérante*.

It is evident, from the account given of the symptoms manifested at the outset of an attack, that these are not sufficiently characteristic to determine the nature of the disease, and in the absence of a prevailing epidemic its early recognition will depend largely upon other facts relating to the antecedents of the patient, etc. The complete clinical history of a case, however, gives a tableau which is easily recognized by one who is familiar with the disease. In this clinical history the thermometric observations form a very important item.

Yellow fever is a disease of a single febrile paroxysm, lasting from forty-eight hours to seven or eight days—more commonly from three to five days. The acme of temperature is reached at the outset, and from this time the temperature line is a descending one, interrupted sometimes by a slight evening exacerbation, up to the termination of the first period of the disease—*febrile stage*. The second stage is characterized by great prostration of the vital powers, and lasts from a few hours to two or three days—*stage of calm*; the temperature during this stage sometimes remains a degree or more above the normal, but more commonly it is normal, or even subnormal for a time. This is followed in severe cases by a *reactionary fever* of irregular duration which presents a more or less remittent character. These features are shown in the accompanying temperature charts.

Naturally the typical temperature curve is disturbed by complications—visceral congestions, abscesses, parotitis, etc. It is also disturbed by indiscretions in diet, over-active medication, and by moral causes (especially fright and grief). In mild cases the acme of temperature is reached during the first two or three hours of the attack. In more protracted and severe cases it is not reached until the second or third day, rarely later. In an analysis of [illegible] cases recorded by [illegible], and myself, the acme was reached on the first day in [illegible], on the second in [illegible], on the third in [illegible], and on the fourth in [illegible]. The temperature rarely, if ever, exceeds 108°. The highest temperature recorded by Faget was 107.2°. Thomson, in a total of [illegible] cases occurring at Memphis, noted a temperature of 108° in a single instance. With

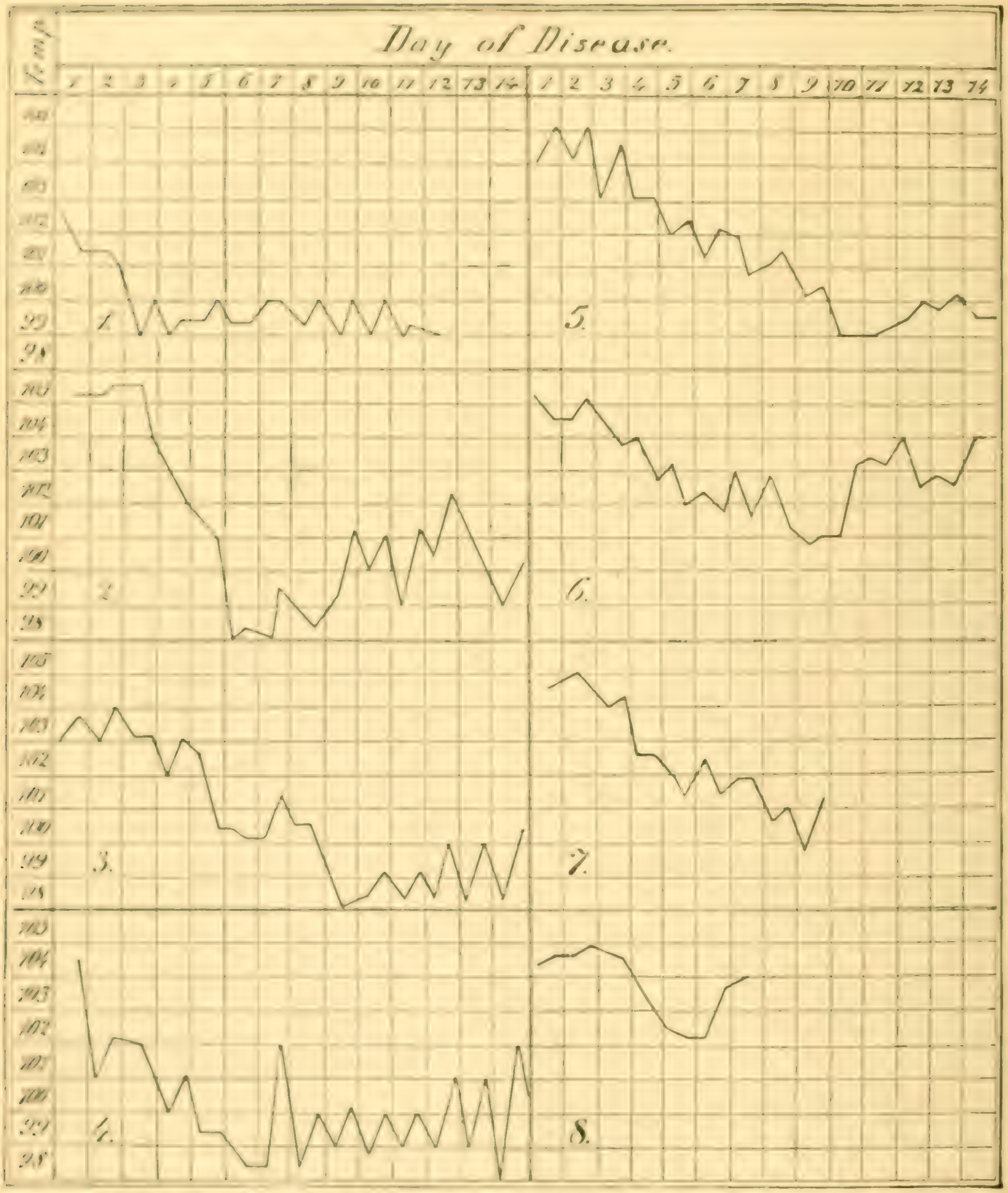

FIG. [illegible].—Temperature Curves of Yellow Fever. 1. Mild case ([illegible]); male aged [illegible]; Fort Barrancas, Fla., 1873 (Sternberg). 2. Typical severe case; recovery; male aged [illegible]; Fort Barrancas, Fla., 1873 (Sternberg). 3. Protracted mild case; recovery; male aged 27; Fort Barrancas, Fla., 1873 (Sternberg). 4. Typical case of moderate severity; recovery; male aged [illegible]; Fort Barrancas, Fla., 1873 (Sternberg). 5. [illegible] (Sternberg). 6. Typical severe case; protracted; death on [illegible] day (Sternberg). 7. Fatal case; death on [illegible] day; male aged [illegible]; Fort Barrancas, Fla., 1873 (Sternberg). 8. Fatal case; "*[illegible]*" (Sternberg).

this exception, 106.5° is the highest temperature recorded by him. In my own observations 106 has been the highest temperature noted. The temperature often rises rapidly just before death, and a very high post-mortem temperature (108° to 110°) is a common phenomenon.

In certain cases the initial paroxysm is divided, by a more or less complete remission, into two or more distinct periods of from two to four days' duration. These cases, which possibly depend upon a malarial complication, are not sufficiently numerous to require a modification of the general statement that yellow fever is a continued fever of a single paroxysm. In relapses, which may occur from imprudence at any time after the termination of the first febrile paroxysm, the characters of the initial paroxysm are repeated, but in non-fatal cases the duration is usually not so long.

The *pulse* in sthenic cases is full, strong, and hard at the outset of the attack, and may reach 120 or more pulsations in the minute, more commonly not more than 100 to 110. It diminishes in rapidity and force as the disease progresses, and this occurs even when the febrile heat is not reduced for two or three days, and is considered by Faget a valuable diagnostic sign. During the second stage of the disease, the pulse, however hard and accelerated it may previously have been, becomes preternaturally slow and soft. The feebleness of the heart, which seems to suffer especially from the action of the yellow fever poison, and which has undergone a certain degree of fatty degeneration, is shown by this very compressible and slow pulse, which is often reduced to forty, and sometimes even to thirty, beats per minute. This constitutes a very characteristic feature of the disease, and affords an important indication for treatment during the period of depression, or "calm."

The *tongue* is sometimes but slightly coated at the outset, and is usually moist ; generally it quickly becomes covered with a white coating, which may be in streaks ; the margins as a rule remain red ; very commonly the tongue is narrow and pointed, differing in this respect from the broad, flabby tongue of the malarial fevers. In the progress of the disease it often becomes dry, and the coating assumes a brownish color, or it may become very foul and loaded with sordes.

The *face* is at first flushed or bright red and swollen, or it may be of a dusky violet hue ; this, with the deep-red suffusion of the eyes in severe cases, is quite characteristic. The countenance often has an expression of anxiety or pain, or of dejection ; again it may appear dull and indifferent.

In the last period of the disease, in fatal cases, the features become shrunken—sometimes bloated and flabby—the brows are often contracted, and the eyes sunken, with ecchymosed lids.

The hyperæmia of the conjunctivæ in mild cases may be temporary, in the more severe ones it is apt to last through the first period, and in quickly fatal cases the eyes may be deeply injected throughout. Usually, by the third day a careful inspection will show that the conjunctivæ have a yellowish tinge which becomes more intense as the disease progresses.

The *skin* is hot and dry in some cases throughout the first period ; in others it soon becomes moist and there is a tendency to free perspiration, which is readily induced by covering with blankets, warm drinks, etc. Even in those cases in which the skin is hot and dry, the termination of the first period is marked by a soft, cool, and usually moist surface. In exceptional cases the skin remains hot and dry up to the fatal termination. When death occurs in the stage of depression, the surface becomes cold and often is covered with a clammy sweat. Many authors have spoken of a peculiar odor given off from the surface of yellow fever patients, and various attempts have been made to define its character by comparison with other known odors. Dr. Rush said that it resembled that of "the washings of a gun." Dr. Jackson describes it as "sickly and faint, and not unlike the smell of a fish-market."

The color of the skin, which has given name to the disease, is not always seen, but usually a yellow discoloration begins to make its appearance toward the end of the first period, and later becomes more intense, lasting for some time after convalescence is established. It varies much in intensity, from a slight yellow tinge to a deep orange or saffron color. In certain cases the skin presents a mahogany color, or that of bronze. In fatal cases the yellow color is developed immediately after death, even if it has not been very noticeable before dissolution took place.

The proportion of cases in which this yellow color of the skin is observed varies greatly in different epidemics, and even in different periods of the same epidemic. Dr. Rochoux states that in the West Indies it is absent in about half of the cases that recover. Bérenger Féraud, referring to this statement, says that there are in fact two kinds of icterus in yellow fever, the one due to blood pigment, denominated by Professor Gubler *hémaphéique* ; the other to bile pigments, and called by the same author *biliphéique*. The first is considered by Féraud to be constant and characteristic ; it occurs at a time when the urine is albuminous and free from bile, and manifests itself about the beginning of the second stage by a yellow tinge of the conjunctivæ, of the face, and of the skin over the great vessels. It coincides with the period during which the hæmorrhagic tendency of the disease manifests itself. The other form of icterus appears at the end of the second period, or during convalescence, at a time when the urine contains a notable quantity of bile pigments ; it gives rise to the deep orange or saffron color of the skin which is so striking, but which only occurs in a certain proportion of the cases, and cannot be considered an essential character of the disease. We are disposed to think that Feraud is quite right in this account of the icterus of yellow fever. A slight yellow discoloration of the conjunctivæ can commonly be detected during the second stage, even in mild cases in which no discoloration of the skin is perceptible.

Various skin eruptions have been described as occurring occasionally, but there is nothing characteristic about any one of them unless it is the erythematous eruption about the scrotum which Bérenger-Féraud believes to be pathognomonic of the disease. Other eruptions mentioned as occurring occasionally are petechiæ, vesicular and pustular eruptions, livid spots and vibices, erythematous patches about the knees and elbows, or a general erythematous eruption, papular eruptions, pustules about the mouth, furuncles, etc.

The *urine* in yellow fever, even during the first period, is reduced in amount below the normal standard. This marked reduction, and in fatal cases very commonly complete suppression, is a notable feature of the disease.

The presence of albumen in greater or less amount, is a symptom which is so constant that it has come to be generally accepted as one of the pathognomonic features of the disease.

The diminution in the amount of the urinary secretion in connection with the amount of albumen present is of importance in a prognostic sense, as it is to a certain extent an index of the gravity of the attack.

The most marked diminution occurs during the stage of depression, and the few ounces secreted in the twenty-four hours, in severe cases, are loaded with albumen to such an extent as to form coagula which occupy one-half to two-thirds of the contents of the test-tube.

In a series of observations made at Fort Barrancas, Fla., in 1875, to ascertain the amount and specific gravity of the urine in non-fatal cases of yellow fever, the writer arrived at the following results.

The *amount*, considered in connection with the *specific gravity*, is, of course, an index of the total solids excreted. In the table we have eliminated from the specific gravity column the constant factor, 1,000. The amount for the first day is no doubt too small, on account of the urine having been only partly collected. It will be noted that the amount increases, while the specific gravity diminishes, from the outset of the attack up to the time of complete convalescence.

Taking the average of eleven non-fatal cases, I obtained the following results:

	Amount.
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

It will be seen that the product of the amount, multiplied by the specific gravity, is tolerably uniform from the third to the twelfth day, and that this uniformity is preserved by a daily falling off of the specific gravity to compensate for the daily increase in quantity. To determine the product of amount multiplied by specific gravity in patients convalescent from yellow fever of a later date, I had the urine passed by sixteen convalescents, on full diet, who had been out of bed from ten to twenty days, preserved and measured. The result was that the average of amount, multiplied by the specific gravity for the sixteen cases, was 981—a product but little in excess of that obtained during the continuance of the fever when the patients were taking no food. The figures in the table may then be taken as representing, approximately, the normal quantity of urinary solids which should be excreted daily during the progress of an attack of yellow fever; and if the amount falls materially below these figures, defective excretion may be presumed, and treatment and prognosis governed accordingly.

In mild cases, only a slight trace of albumen may be found in the urine for a day or two, but usually the deposit is sufficiently abundant after the second day to leave no doubt as to its character. It becomes more abundant at the termination of the first stage, and in severe cases throughout the stage of calm, at which time suppression is very liable to occur, especially if, as a result of exposure, the cutaneous transpiration is checked. The early appearance and abundant presence of albumen is generally regarded as an evil prognostic. The reappearance of albumen, after it has once disappeared, indicates a relapse.

The amount of urea eliminated by the kidneys is less than normal, and in inverse proportion to the severity of the attack. According to Corlisle, the quantity is generally in proportion to the amount of urine secreted, and when the amount increases it is a favorable symptom. Uric acid is also said by this author to be present in diminished quantity, but in much less proportion than the urea. He says: "We have seen urine, containing only seven grams of urea per litre, give a relatively abundant deposit of uric acid." Bile pigments usually appear in the last days of sickness, and their presence is generally considered a favorable prognostic sign. In exceptional cases the urine may contain blood, from renal or vesical hemorrhage. The urine in yellow fever almost invariably presents a decided acid reaction.

The symptoms connected with the nervous system are varied. In mild cases the intellect remains undisturbed, and only a moderate amount of transient pain in the head and back marks the onset of the attack. In severe cases the frontal headache and rachialgia are most distressing, and may last throughout the first period of the disease. This stage is also one of great restlessness and jactitation; the patient sleeps but little, and his sleep is apt to be disturbed by distressing dreams; the mind often seems to be in a state of tension, the patient is watchful, excited, and anxious. In other cases the mind is calm, and in others, again, there is a condition of apparent apathy or indifference. Delirium is not a very common symptom in yellow fever, and the intellect often remains unclouded throughout, even in fatal cases. Some cases, however, are attended with incoherency of ideas, or hallucinations, and in some there is active delirium. More frequently the mind falls into a torpid condition; the patient is somnolent, and, when awakened, is disposed to be taciturn. A certain number of fatal cases are characterized by active delirium, followed by coma, and a greater number by coma gradually developed. In a limited number of cases death is preceded by convulsions, and occasionally tetanic symptoms of more or less general character have been noted. Among the nervous symptoms may be mentioned deep sighing respiration, sometimes of a suspirious character. Naturally the respiration is increased in frequency during the febrile stage. In the stage of calm it again becomes normal in mild cases, or rapid and spasmodic in those of a graver character.

There is complete anorexia during the first stage of the disease, but when the remission occurs patients are very likely to crave food, and even to insist upon having it. Thirst is a constant symptom during the febrile stage, and also in the second period, especially when there is frequent and copious vomiting—black vomit. The bowels are commonly somewhat constipated at the outset. In the second period of the disease there is apt to be more or less diarrhœa, and in fatal cases a dark fluid is often discharged from the bowels, resembling precisely that from the stomach. Occasionally there is a discharge of pure blood, the result of intestinal hemorrhage. A choleraic form of the disease is sometimes met with, in which there is profuse diarrhœa and collapse, similar to that in the algid stage of Asiatic cholera.

Symptoms connected with the stomach form a prominent part of the clinical history of yellow fever. The characteristic black vomit which has so much occupied the attention of medical authors, is for the vulgar the most striking feature of the disease, and even many physicians reserve their diagnosis in early cases during an epidemic until they have had ocular evidence that the vomited matter is black. The common name of the disease in Spanish countries—vómito—refers to this symptom. Yet in a majority of the cases there is no vomiting of black matter. Indeed, this is recognized as a very grave symptom, and although a considerable number of recoveries occur after the characteristic black vomit has been ejected, this may be considered an exception to the general rule.

Vomiting is a common symptom during the first period of the disease; sometimes the fluid ejected has a yellow color from the presence of bile, but more frequently it is colorless and consists only of the fluids ingested, containing, in suspension, a little mucus from the stomach; it is almost always acid. In favorable cases vomiting ceases with the first period of the disease; in those of a graver character, after an interval, perhaps, of twenty-four hours or more, during which there is more or less gastric distress—a feeling of weight and discomfort, vomiting again occurs, either of a clear acid fluid, or of one of the varieties of black vomit. At first the black material may be in the form of little flocculi suspended in a transparent fluid—"coffee-grounds vomit," and as the case progresses the amount of this material increases until the whole fluid appears to be uniformly black. Upon allowing it to stand, however, it will be seen that it still consists of a clear liquid with the black matter in suspension. Upon microscopic examination it will be found that the colored material is made up of little masses which are not black, but have a yellowish-brown color. A careful examination of recent specimens shows that these little masses contain decolorized and more or less deformed red blood-corpuscles, also granular leucocytes, and that the brown matter is diffused about these agglomerated cellular elements, and the matrix of mucus in which they often seem to be imbedded. There is no doubt that the black vomit is due to passive hemorrhage from the gastric mucous membrane, although this has been disputed by some recent authors—Freire, Carmona, others. Formerly it was maintained by some that the black matter was a secretion from the stomach, and by others that it was "altered black bile." I have myself repeatedly verified the fact by microscopic examination, that it contains the cellular elements of the blood. In certain cases there is vomiting of pure blood, resulting from more active gastric hæmorrhage. The black vomit is not always discharged during life, but it is extremely rare not to find it in the stomach after death.

The fact that the gastric mucous membrane is seriously involved in this disease is shown not alone by the vomiting, the passive hæmorrhage, and the post-mortem appearances, but also by the constant feeling of discomfort or pain in severe cases, and by a marked tenderness upon pressure over the epigastrium.

Hæmorrhage may occur not only from the mucous membrane of the stomach and intestine, but also from that of the mouth, nose, bladder, and uterus, and even from the eyes or ears. In some epidemics epistaxis is quite common; it may occur during the first period of the disease, but is more frequent during the second, at which time the general tendency to hæmorrhage is developed. Next to epistaxis, hæmorrhage from the buccal mucous membrane, and especially from the tongue, the gums, and the lips, is the most frequent.

In mild cases of yellow fever, *convalescence* is quickly established. Instead of the usual depression which marks the second stage of the disease, the patient, after a fever of three to five days' duration, may enter almost immediately into convalescence, and within a week may be ready to resume his usual avocations. But in severe cases, convalescence is often slow and may be interrupted by various *complications*—parotitis, buboes, furuncles, abscesses, hepatitis, diarrhœa. In the army, experience shows that but few of those attacked are able to resume their duties in less than ten days, and a considerable number remain in hospital from thirty to fifty days. Blair found the average number of days, during which patients were retained in hospital after convalescence was established to be 6.55 for mild cases, and 7.91 for grave cases.

Relapses occur for the most part during the early period of convalescence, or before it is fairly established; they are generally regarded as even more dangerous than the first attack. Occasionally a relapse, or second attack, occurs as late as from two to four weeks after the termination of the febrile period of the first attack.

PROGNOSIS.—The prognosis in yellow fever should always be guarded, for not only is it a very fatal disease in its severer forms, but cases which appear mild at the outset may suddenly assume a grave character. It is more favorable in the case of women and children than with men, and is especially unfavorable in those of intemperate habits, and in plethoric persons who have recently arrived in the infected locality. The principal guide in forming a prognosis at the outset of a case is furnished by the temperature observations. When the body heat does not go above 103° to 103½° F. during the first two days, a favorable result may be anticipated. Later, the amount and character of the urinary secretion is the most important prognostic indication. When this is scanty and heavily loaded with albumen, the case is very grave, although the general appearance of the patient may be favorable, and he may insist that he is "all right" and wants something to eat. On the other hand, hopes of a favorable issue may be entertained even in cases characterized by great prostration, and in which the hæmorrhagic tendency is pronounced, if the urinary secretion is tolerably abundant and the quantity of albumen small. The throwing up of black vomit is by no means a fatal sign, but as a rule the passive hæmorrhages which occur during the second stage of the disease are of grave import. Epistaxis occurring during the first stage has been considered by some authors a favorable event (?).

The early appearance of jaundice is an unfavorable sign; as is also frequent vomiting, and great distress and tenderness in the epigastric region. Intense and long-continued injection of the conjunctivæ, giving the eyes a fiery-red color, is unfavorable. Delirium, great restlessness and jactitation, and sighing respiration, are all symptoms which give reason for anxiety as to the result.

The prognostic indications as furnished by temperature observations are shown in the following table, made by the writer, some years since, from a series of cases in which a complete and careful record had been made:

Cases in which the temperature was	No. of cases.	No. of deaths.	[illegible]
107° and above	13	13	[illegible]
106° — 107°	9	9	[illegible]
105 — 106	[illegible]	22	[illegible]
104° — 105°	[illegible]	24	[illegible]
103 — 104°	[illegible]	6	[illegible]
102 — 103°	26	1	[illegible]
101° — 102°	15	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]

MORTALITY.—The mortality from yellow fever varies greatly in different epidemics and among different classes of the community.

Among the natives of cities in which the disease is endemic, or in which it has frequently prevailed as an epidemic, it may be as low as from seven to ten per cent. One reason for this comparatively small mortality is found in the fact that a considerable proportion of the cases in such a community are among children. Among unacclimated adults the mortality ranges from twenty to sixty per cent., and under certain circumstances even exceeds the latter figure. In the great Philadelphia epidemics of the last and the beginning of the present century, the mortality was from twenty to eighty per cent. In the French Antilles, according to Dutrouleau, the mortality during the years 1851 to 1857, inclusive, ranged from 12.9 per cent. to 50 per cent. Blair gives the mortality at the Seaman's Hospital at Georgetown (Demerara) in 1838 as 19.5 per cent.

At Vera Cruz the mortality for seven years (1875–1881), according to Dr. Molina's statistics, was 41.78 per cent. in the hospital for men, and 41 per cent. in the hospital for women. In Rio Janeiro the mortality for the year 1870 was 17.4 per cent. In the epidemic of 1873, it was 23.3 per cent.

The mortality among the Spanish troops in Cuba, according to the statistics of Dr. Bastarreche, was, in the year 1855, 24.31 per cent., and in the royal navy 17.8 per cent.

Dr. Bemiss gives the mortality-rate for the city of New Orleans, during the great epidemic of 1878, as 16.66, and classifying the cases according to age, has constructed a table which we have used on a preceding page (page 52).

The day of death is given by Bérenger-Féraud as follows, in a total of 1,059 cases occurring in the French Antilles:

Died on the second day, 16 = 1.5 per cent.; third day, 56 = 5.3 per cent.; fourth day, 141 = 13.4 per cent.; fifth day, 165 = 15.7 per cent.; sixth day, 177 = 16.9 per cent.; seventh day, 151 = 14.3 per cent.; eighth day, 89 = 8.5 per cent.; ninth day, 42 = 3.9 per cent.; tenth day, 35 = 3.3 per cent.; eleventh day, 28 = 2.6 per cent.; twelfth day, 34 = 3.2 per cent.; thirteenth day, 25 = 2.3 per cent.; fourteenth day, 21 = 1.9 per cent.; fifteenth day, 8 = 0.7 per cent.; sixteenth day, 7 = 0.6 per cent.; seventeenth day, 13 = 1.2 per cent.; eighteenth day, 6; nineteenth day, 6; twentieth day, 7; twenty-first day, 3; twenty-second day, 2; twenty-third day, 5; twenty-fourth day, 3; twenty-fifth day, 3; twenty-sixth day, 5; twenty-seventh day, 1; twenty-eighth day, 1; twenty-ninth day, 2; thirtieth day, 1; thirty-first day, 3; thirty-second day, 1; thirty-third day, 1; thirty-sixth day, 1. This table shows that sixty-seven per cent. of the whole number died during the first week, and eighty-two per cent. during the first ten days. In a similar table constructed by Dr. Clements, of the United States Army, out of a total of 111 fatal cases, death occurred, during the first week, in seventy-three per cent.; during the first ten days in eighty-two per cent.

DIAGNOSIS.—Notwithstanding the well-marked features of a typical case of yellow fever it very often happens that the early cases in an epidemic are not recognized, and even in fatal cases, with the assistance of an matoms, objections are practically common with the disease often called mild the diagnosis. At the outset of an attack, indeed, there is nothing sufficiently characteristic in the symptoms to enable one, as a rule, to decide definitely that the case is yellow fever, although there are certain indications which may give him a strong suspicion that it is. The frontal pain, flushed face, gastric distress, injected conjunctivæ, pains in the back, etc. When such a case occurs during the epidemic prevalence of yellow fever, in a stranger, or in one not acclimated, the inference naturally is that the individual has yellow fever; but this inference is sometimes mistaken, and more than one stranger is sent to the yellow fever hospital—himself who is, to his surprise, was later found to have some other febrile complaint, sometimes one of the eruptive fevers. A case in one of our own seaports, having with precisely the same symptoms occurring at a time when yellow fever was not prevailing, would almost infallibly be pronounced "remittent fever," or "bilious fever," or "congestive fever," as soon as it was evident that it was not one of the specific eruptive fevers. And that diagnosis would very probably be maintained, if no evidence could be found that the individual had been exposed to yellow fever, even if the further clinical history of the case corresponded with that of this disease. It is in this way that outbreaks of cases occurring in the practice of several different physicians at the outset of an epidemic are frequently called by some other name.

The fact that the early cases in an epidemic are sometimes of a mild character adds to the liability to error. A man has a chill followed by fever, and receives in the next forty-eight hours several full doses of quinine; at the end of this time his fever has disappeared, and, with the exception of a certain amount of debility, and perhaps an irritable stomach, he feels quite well. The inference is that he had an attack of malarial fever which was cut short by the treatment; perhaps it was so, but the inference is the same in either case. I have seen cases in the hospitals of Vera Cruz, for example, in which there was a slight amount of albumen in the urine, and in which the depression and slow pulse following a single febrile paroxysm of brief duration seemed to me to be characteristic of a mild attack of yellow fever, but in which the diagnosis was malarial fever, and the brief duration of the attack was ascribed to the full doses of quinine which had been administered. I have seen precisely similar cases during the prevalence of an epidemic of yellow fever, in which no quinine was given, and in which, notwithstanding, the febrile paroxysm was of brief duration and did not return. For example, the case represented by chart 1, in Fig. 5068. This case by itself would not have been diagnosed as yellow fever, but occurring as it did, with several others of the same mild character, side by side with severe and fatal cases of this disease, I did not doubt that it was due to the same specific cause, and was in fact a case of yellow fever. The occurrence, in a southern seaport, of a group of cases of so-called malarial fever, in a particular locality, especially among the colored population, should always arouse suspicion and lead to investigation. When in such a city, or in any place within the limits of yellow fever invasion, and during the summer months, we hear that a "malignant form of malarial fever" has appeared in a certain limited area, a single house or square, or district, we shall not be apt to go wrong in the inference that the disease is yellow fever. Malignant forms of malarial fever belong to the country rather than to the city, and cases do not occur in groups, within city limits, where the malarial poison is not prevalent in its most intense form, if at all. Formerly, very much uncertainty as to diagnosis arose from mistaken ideas as to the etiology of the disease. A considerable number of physicians in the United States maintained that yellow fever and the malarial fevers are closely allied, if not identical, diseases, due to the same general causes, and the idea was very prevalent that, under the influence of meteorological conditions, a mild form of malarial fever might be transformed into the malignant yellow fever. Under this idea, physicians felt justified in calling the mild cases in an epidemic malarial fever, and in reserving the name yellow fever for those in which a yellow skin, highly albuminous urine, and black vomit would make up the classical triad to which they gave the name yellow fever. Of these three prominent features only one is a constant character which can serve in establishing the diagnosis in mild cases. This is the presence of albumen in the urine. At some period of the disease, even in the mildest cases, there will be a distinct trace of albumen in the urine, as shown by the usual tests, and this will generally be sufficiently abundant to leave no doubt in the mind of the observer as to the nature of the precipitate. In sixty-one cases occurring during an epidemic in Jamaica, Jackson found albumen present for the first time, in 2 cases on the first day; in 11 cases on the second day; in 19 cases on the third day; in 14 cases on the fourth day; in 9 cases on the fifth day; in 4 cases on the sixth day; in 1 case on the seventh day; in 1 case on the eighth day. It will be seen that, in by far the larger number of cases, the presence of albumen was revealed on the second, third, or fourth day. The value of this test in the differential diagnosis of yellow fever is indisputable. It is true that a trace of albumen is sometimes found in the urine of severe cases of fevers of malarial origin, but in cases of yellow fever of equal severity, as compared with these, the precipitate would, as a rule, be very abundant on the third or fourth day of sickness, forming a deposit to the extent of one-fourth to one-half the contents of the test tube, or even more. At the same time a microscopical examination would show the presence, in the urine, of numerous granular casts from the tubuli uriniferi. These are found also, although in a smaller number, in the urine of the milder cases during the second stage of the disease. For diagnostic purposes the character of the febrile paroxysm, and especially the phenomena following this which mark the second stage of the disease, are the most important. The characteristics of the temperature curve are sufficiently shown by the charts of typical cases in Fig. 5068. It must be remembered, however, that while the stage of depression is commonly marked by a normal, or even subnormal, temperature, in a considerable number of severe and fatal cases the temperature still remains a degree or two above the normal when the cool skin and slow, soft pulse would indicate, if the thermometer were not used, that there was complete apyrexia; or again the skin remains dry, and the patient falls into a typhoid condition with a fluctuating temperature, without having had a complete remission of febrile heat. The second stage of the disease is, however, commonly well marked in non-fatal cases, and is its most characteristic feature; the remarkably slow and soft pulse, the evident prostration of the vital powers, although the patient may be comfortable, and even cheerful, and desirous of getting up, or of taking food; the yellow tinge of the conjunctivæ and skin—not always present; the tenderness on pressure in the epigastric region, and often a feeling of weight and distress in this region, attended with intense thirst and vomiting of a transparent acid fluid, or of the characteristic black vomit; the tendency to passive hæmorrhage from the mucous surfaces of the mouth or nose, oozing of dark blood from the gums, or lips or sides of the red and fissured tongue; the scanty urinary secretion, and the presence of albumen, usually in considerable amount; all of these symptoms constitute an ensemble that for the practised eye and hand is unmistakable.

The differential diagnosis from bilious remittent fever, with which yellow fever has frequently been confounded, is not always possible at the outset of an attack, but the contrast in the complete clinical history of the two diseases is sufficiently striking. Remittent fever, as the name indicates, is characterized by periodical remissions of the febrile heat; this is, however, in severe cases often not well marked, so far as exact thermometric observations are concerned, and is rather a remission usually occurring in the morning, of the general symptoms—headache, vomiting, heat of surface, rapidity of pulse—than a decided lowering of the body heat, as shown by the thermometer placed in the axilla. But, as a rule, an attack of remittent fever is made up of a series of paroxysms, each of which may be inaugurated by a more or less distinct chill; while yellow fever is essentially a disease of a single paroxysm, in which, as shown by our charts, the acme of temperature is reached early in the attack, and the remission is characterized by a descending line extending often through a period of three or four days. In remittent fever, on the contrary, the fall attending the remission is an abrupt one. The tongue in remittent fever is usually heavily covered with a yellowish or brownish coating, it is broad, and often marked upon the margins by indentations made by the teeth, showing that it is swollen. In yellow fever the tongue is usually narrow and pointed, often tremulous; at the outset of an attack it may be comparatively clean, or it is covered with a thin, white, or heavy cottony coating—occasionally yellowish. The yellow color of the skin in bilious remittent fever, does not differ from that of simple jaundice, and is very persistent when developed; it is, however, far from being a constant symptom. The same is true of the jaundice which is occasionally developed during convalescence from yellow fever. But, besides this, there is a more or less pronounced yellow tinge of the conjunctivæ and skin in yellow fever, which appears during the latter part of the first, or early in the second, stage, and which in convalescence quickly disappears. In fatal cases this yellow color is more pronounced, and may assume a dingy brown or mahogany color; the dependent portions of the body after death have a livid, mottled appearance, and the discoloration resembles that following a bruise which has produced an effusion of blood. In the malarial fevers the spleen is more or less swollen and tender, while in yellow fever it is not involved. In yellow fever the intellectual faculties are commonly unimpaired, at least during the febrile stage, and often up to the moment of the fatal termination; on the contrary, delirium is quite common in severe attacks of bilious remittent fever. In yellow fever vomiting of bilious matter is rare, and only occurs, if at all, at the outset of the attack; while later, the vomited matter consists of the fluids ingested, or of a transparent acid fluid containing flocculi of mucus, or of one of the varieties of black vomit; in remittent fever the vomited matters are nearly always colored with bile—indeed, bilious vomiting is commonly a marked feature of the disease. In remittent fever, according to La Roche, the quantity of uric acid in the urine is notably increased, being in some cases eight times as great as in health; in yellow fever it is diminished—the amount of urea is diminished in both diseases. Suppression of urine is extremely rare in bilious remittent fever, and extremely common in fatal cases of yellow fever; the uniform presence of albumen in the latter disease has already been noted. Finally, the marked hæmorrhagic tendency in yellow fever distinguishes this disease from bilious remittent fever.

There is a form of malarial fever, however—the so-called "hæmorrhagic malarial fever"—which is characterized by the periodical appearance of blood pigment in the urine, with sometimes a tendency to hæmorrhage from mucous surfaces. This is the *fièvre bilieuse mélanurique* of the French authors. The clinical history of this disease differs entirely from that of yellow fever. The distinguishing characters are given by Bérenger-Féraud as follows:

"Prolonged residence in a malarial country is the most powerful and, indeed, indispensible predisposing cause.

"The disease is always preceded by numerous attacks of malarial fever, simple at first, then more and more complicated, and taking in general more and more of a bilious aspect, producing a very decided anæmia.

"Icterus appears at the outset of the attack, and is never wanting; it gives from the commencement and throughout the attack a uniform yellow color to the patient, varying from greenish-yellow to a decided yellow ochre.

"The march is intermittent or remittent from the first, and the pulse, urine, and vomiting follow very exactly the variations of temperature. . . .

"The vomiting is bilious, of a decided green color; it is a constant symptom at the outset of an attack, it is arrested with the termination of one attack to reappear with the next.

"After the first, or febrile, period the vomiting continues, but preserves the same characters; it stains linen a bright green, and when collected in a basin it appears transparent, and is of a beautiful emerald green, or olive color.

"The tongue is moist, broad, covered at first with a heavy white fur, which soon receives a greenish tint from the vomited matters. The tongue is not red, either upon its tip or edges; it remains broad, heavily coated, and moist to the end of the malady.

"The urine is black from the commencement, and its color is characteristic, so that the patient himself is struck with it. It is usually abundant and frequently passed, and only has the melanuric aspect during the attack."

In malarial hæmaturia, as seen in this country, the urine varies in color according to the amount of blood pigment present, from a light red to a deep claret, or porter color. It is usually acid, and always albuminous. The presence of red blood-corpuscles has frequently been demonstrated by microscopical examination, and tube casts, made up of granular matter and red corpuscles, are often present in the urine. In the gravest form of the disease the patient falls into a typhoid condition, and at this time epistaxis is likely to occur, or there may be, in rare cases, hæmorrhage from the stomach or bowels.

The differential diagnosis between yellow fever and dengue will depend mainly upon the fatal character of the first-mentioned disease, the presence of albumen in the urine, and the hæmorrhagic tendency, as contrasted with the absence of these features and the skin eruptions and arthritic pains in the other. Dengue, like mild yellow fever, often terminates, after a febrile stage of forty-eight hours' duration, in complete apyrexia, and the patients are able to resume their ordinary occupations, although feeling stiff and sore when making any movement; more frequently there is a return of the fever, attended by a rubeoloid eruption, which ends in desquamation, and is accompanied with a return of the arthritic and muscular pains. This stage may last but three or four days, or may be of much longer duration; but in any case the disease is not attended with danger to life.

The *bilious typhoid* of Griesinger presents some points of resemblance with yellow fever, but the clinical and pathological features are sufficiently distinct to make it improbable that errors in diagnosis will occur when due care is taken.

Quite recently, Dr. Diamantopulos, of Smyrna, has given an account of a disease under the name *typhus icteroides*, which is said to be distinct from the bilious typhoid of the German authors, and which prevails upon the coast of the mainland, and upon the islands of the Ægean Sea. This name has frequently been applied to yellow fever, which the disease described resembles in many particulars, although no doubt distinct from it. It prevails in the summer and autumn. The attack begins with a chill, followed by fever, intense headache pain in back and limbs, jactitation, etc. The eyes are described as injected, glistening, and humid; the epigastrium is tender on pressure, the liver and spleen are more or less enlarged. There is a remission of the fever on the third or fourth day, and the second stage is inaugurated by a general improvement in the appearance and feelings of the patient; later (fifth or sixth day), icterus is developed; this is intense, giving to the whole surface a golden or orange-yellow color. Epistaxis is frequent in this stage, and hæmorrhage from the bowels, bloody urine, and petechiæ in certain cases, show that the disease has a hæmorrhagic tendency. It is said to prevail endemically, or as an epidemic, and to be miasmatic and not contagious. Perhaps this is the same disease as was epidemic on the island of Mauritius, in 1867, an account of which has been given by Pelleran in the *Archives de Médecine navale* (tome 36, 1881). This author, after stating that up to the year 1867, the opinion was generally entertained that malarial fevers did not exist in Mauritius, goes on to say that in 1807): "The effects were terrible, and so common that the sickness was ascribed to impregnation." One of the epidemics, quoted by Pelletan, gives the clinical features as follows: "The patient fell suddenly as when in perfect health, often after a full meal. The skin became hot, the face red, the eyes injected; the pulse mounted to 90 or 100; the skin became yellow, the tongue dry and glossy; precordial anxiety, accompanied by a small cough and exceedingly foetid pains; afterward followed intense prostration, with intolerable pain in the lumbar region and region of the liver. The poor patient, after twenty to thirty hours, died in a state of collapse closing a period of ... Another character of the fever was its tendency to relapse, to occur at all seasons of the year, in dry, elevated localities as well as in those which were low and humid, and to be accompanied by hæmorrhages."

It is evident that these fevers, if they prevailed in the same country as yellow fever, might give rise to confusion in the diagnosis, and also that our knowledge of the pathology of tropical fevers is far from being complete.

Many of the physicians practising in the French Antilles recognize a fever called by them fièvre inflammatoire, as distinct from yellow fever. Bérenger-Féraud has shown, however, that it is in fact identical with this disease, and only represents one of its grades of severity.

PATHOLOGICAL ANATOMY AND HISTOLOGY.—The exterior of the body of an individual who has recently succumbed to yellow fever presents an appearance which is quite characteristic. The icteric color of the skin, although often not too marked during the last hours of life, is developed in a large majority of the cases very soon after death. The color is that which is seen to follow a bruise in which there has been an effusion of blood, and the origin of the pigment is no doubt the same. The icterus from bile pigments, which occurs not infrequently during convalescence, and which may be seen in cases fatal from a relapse or at a late period of the disease, gives a uniform saffron-yellow color to the surface of the body and conjunctivæ. In the icteric discoloration of which we speak at present the color is not so intense and not so uniformly distributed. The depending portions of the body, and especially those subjected to pressure, have a deeper coloration, and are more or less livid and mottled from hypostatic congestion. Dutroulau has shown that this ecchymotic appearance of the back is due to position and pressure by placing the body upon the abdomen or side. In this case it is also the most dependent part which shows the livid mottled appearance referred to. The face and hands frequently appear congested, or the face may be livid and turgescent like that of one recently drowned. A little stream of black vomit is frequently seen trickling down from the corners of the mouth, or a similar fluid may escape from the nostrils, and the lips and gums may be soiled with dark blood which has oozed from them.

Cadaveric rigidity is quickly established and well marked.

The appearances observed upon removing the calvarium are usually those of hyperæmia of the brain and its meninges. The pia mater is almost always congested, and the vessels of the brain are commonly full of blood; the pons and medulla are generally in a condition of hyperæmia. There is more or less effusion into the subarachnoid space and in the ventricles; this is sometimes turbid and has a yellow color. The surface of the brain presents sometimes little hæmorrhagic points, and its substance, like the tissues of the body generally, has a more or less pronounced yellow tinge.

Dr. Schmidt, of New Orleans, has described certain pathological changes in the sympathetic ganglia, which he believes to be important. "In a majority of the cases examined by him the minute blood-vessels of the ganglia were found to be filled with blood-corpuscles. In two cases the ganglionic bodies of the first thoracic, as well as of the semilunar ganglion, had undergone granular degeneration. In the greater part of these ganglion-cells the nuclei had entirely disappeared, leaving no other trace but their outlines, which were very distinct. In the rest very faint outlines of the nuclei could still be observed. The bodies of all these ganglion-cells presented an indistinct appearance, and were characterized by a peculiar fatty lustre, even observed in specimens mounted in Canada balsam."

Usually the lungs present no evidence of pathological changes; occasionally they are congested and contain hæmorrhagic infarctions.

The fluid in the pericardium is often increased in amount and has a yellow color; in rare cases it contains blood. The heart is commonly paler than normal and, according to some authors, is often soft and friable owing to fatty degeneration of its muscular tissue (Riddell, Schmidt). This is denied by others (Crevaux, Guiteras, Gama Lobo). Woodward, who examined the material brought back by the Havana Commission of 1879, agrees with Guiteras that his sections did not present any decided evidence of fatty degeneration, but remarks: "This by no means proves that it does not occur in certain cases, perhaps in certain groups of cases."

Several of the most competent observers agree that there is a fatty degeneration of the walls of the small blood-vessels and capillaries of the various organs, and account in this way for the hæmorrhagic tendency of the disease. This is certainly a more rational explanation than the one so frequently offered, viz., that the hæmorrhages are due to the disorganized and diffluent condition of the blood. A moment's reflection should show that this explanation is insufficient, and that the blood, however diffluent, cannot escape so long as the vessels are intact. Ecchymotic points, or hæmorrhagic infarctions, are sometimes found upon the surface or in the substance of the heart, as well as in other muscles of the body and the organs generally. The cavities of the right side of the heart usually contain soft coagula or dark-colored fluid blood, and the right ventricle sometimes contains a more or less decolorized fibrinous clot.

The blood in yellow fever has been described by many observers as "completely disorganized" as to its histological elements. This is a mistake, as is shown by the numerous photo-micrographs made by the writer while in Havana, in 1879, from the blood of cases near a fatal termination. Both the red and the white corpuscles retain their normal appearance, and I have frequently seen the leucocytes undergoing their characteristic movements, even after twenty-four hours, in blood which had been preserved in culture-cells. In the days of bleeding numerous observers mentioned the fact that the blood does not coagulate readily, or forms a soft, loose coagulum, from which the serum does not separate. The same is true of the blood in the heart and large vessels after death; it is fluid and dark colored. Although there is no general destruction of the red corpuscles, it is probable that a considerable number of these elements perish in severe cases, for the serum contains free hæmoglobin, which gives it a yellow color, even as early as the third or fourth day. This yellow color is seen in the serum obtained from the application of blisters to the surface, and in blood drawn for microscopical examination. In blood obtained near the termination of a fatal case, and in post-mortem blood, this color is very pronounced, and increases in intensity by further solution of the hæmoglobin when the specimen is kept for a time; in the meantime the blood disks become paler than normal. In specimens kept in culture-cells I have observed the formation of beautiful crystals of hæmatoidin. This passing of the hæmoglobin into the serum, which is no doubt the cause of the yellow discoloration of the tissues in yellow fever, has been ascribed to the presence of bile. This view is not sustained by the chemical researches of Cunisset, a recent French author, who has arrived at the following conclusions:

"Yellow fever is not a poisoning by the bile; at the outset of the malady the biliary pigments are rarely found in the blood or in the urine. They appear generally only during the second period, and in a great number of cases they are not to be found at all.

"The biliary salts, to which the powerful action of 'cholæmia' admitted by certain authors might explain the disorders which the malady presents, do not exist either in the matters vomited, or in the urine, or in the blood, except, in certain cases, in very feeble quantity. In view of the profound alterations of the liver, this absence of the biliary salts is easily understood, and the defective depuration of the blood is to be looked upon as a complication rather than a determining cause of the malady."

Schmidt says: "The icterus in yellow fever is not owing to the presence of bile in the blood, as is believed by a large number of physicians, but to the presence of free hæmoglobin, and represents in truth the so-called 'hæmatogenous' jaundice. A 'hepatogenous' jaundice cannot take place, as the larger as well as the smaller hepatic ducts are found perfectly open, and as the secretion of bile during the disease, in the majority of cases, is rather diminished, or even suspended."

The white blood-corpuscles have seemed to the writer to be rather reduced in number toward the end of fatal cases; in specimens of blood mounted dry for microscopical examination they are frequently seen to contain one or more highly refractive granules, the exact nature of which has not been determined, but which I suppose to be fat. There are no micro-organisms present in the blood of yellow fever demonstrable by the usual methods of staining and microscopical examination, or by cultivation in the media commonly employed by bacteriologists.

The most important pathological changes in yellow fever are found in the organs contained in the cavity of the abdomen. The mucous membrane of the *stomach* is always found to be more or less hyperæmic; the congestion is commonly not general, but is confined to smaller or larger spots or districts, in which it is observed to proceed from one or more centres. From these centres it extends or radiates in a lesser degree, either gradually to be lost, or to pass over to another congested district. It is owing to this peculiarity of the congestion that it presents no uniformity of character, but is observed to spread irregularly over larger or smaller portions of the membrane (Schmidt). In addition to these congested patches, there are often to be seen small red patches resembling ecchymoses, but which, according to Schmidt, consist of "an unbroken network of minute vessels congested with blood, and identical with that network of large capillaries which surrounds the aperture of the gastric glands." Crevaux believes that a fatty degeneration of the cells which line the gastric glands and the capillaries of the mucous membrane is the most important lesion here. Other authors speak of an acute gastric catarrh as the process indicated by the appearance and histological examination of the mucous membrane; others again deny that there is any inflammation. My own examination of thin sections stained in various ways, shows that in a certain proportion of the cases there is evidence of inflammation, as shown by the presence of an unusual number of leucocytes in the submucous coat.

It has been asserted that the epithelium of the stomach undergoes fatty degeneration. This is denied by Schmidt. The dark fluid so often ejected during the last hours of life, known as *black vomit*, is almost always present in the stomach, in greater or less amount, after death. There is no question that the dark color is due to the presence of blood pigment, more or less changed by the acid secretions of the stomach. The best authorities everywhere are in accord on this point, which has, however, recently been called in question by Carmona, Freire, and Gibier. These gentlemen suppose the black pigment to be a product produced by the vital processes of a specific micro-organism. The two first-named authors base their opinion, that the color is not due to blood pigment, upon the negative results of their spectroscopic experiments. Dantec remarks with reference to this: "Every-one knows that the derivatives of hæmoglobin (hémaphéine, hématine, etc.) are insoluble in water; it is then not astonishing that MM. Domingos Freire and Carmona have not obtained any spectroscopic result, since the first condition is to examine the body in a liquid state. Upon dissolving the black matter with acidified alcohol, we have always obtained positive results." The author just quoted has repeated an experiment often made in this country, at a time when the question was whether the vomited matter consisted of "black bile," or derived its color from the blood. By adding some drops of hydrochloric acid to blood diluted with water, Dantec produced an "artificial black vomit" which resembled exactly that ejected from the stomach of yellow fever patients.

The small *intestine* commonly contains more or less black matter, either fluid and resembling that found in the stomach, or mixed with mucus and smeared over the mucous coating, especially of the ileum. This, no doubt, comes partly from the stomach, but in other cases is due to passive hæmorrhage from the mucous membrane of the intestine itself. This membrane presents arborescent patches of congestion, or portions of the canal may be uniformly red from hyperæmia of the mucous coat, the color varies from pale red to a reddish-brown, and is usually more marked in the lower portion of the ileum than elsewhere. The large intestine occasionally presents similar arborescent patches of congestion, but usually it has a normal appearance. Finally, we may say that the attention of pathologists has heretofore been so largely taken up with the pathological histology of the organs which present the most notable changes—liver and kidney—that the histology of the alimentary canal has been somewhat neglected, and further researches in this direction are desirable upon material obtained at the earliest possible moment after death.

The appearance of the *liver* in yellow fever is characteristic, at least so far as acute febrile diseases are concerned. Usually it contains less blood than in the normal condition, and is of a pale yellow or brownish yellow color, similar to that of new leather in its various shades; occasionally it is gorged with blood, and livid, deep blue, or dark purple in color. In the victims of chronic alcoholism, it often presents the nutmeg appearance of cirrhosis. The dimensions do not differ materially from the normal, but the consistence is modified by the fatty change, which gives the characteristic color, and the parenchyma is easily torn and more or less friable. On section it is found to be drier than in the normal state, except in the comparatively few cases in which it is hyperæmic; these are, as a rule, cases which have proved fatal at a very early period—a fact which indi

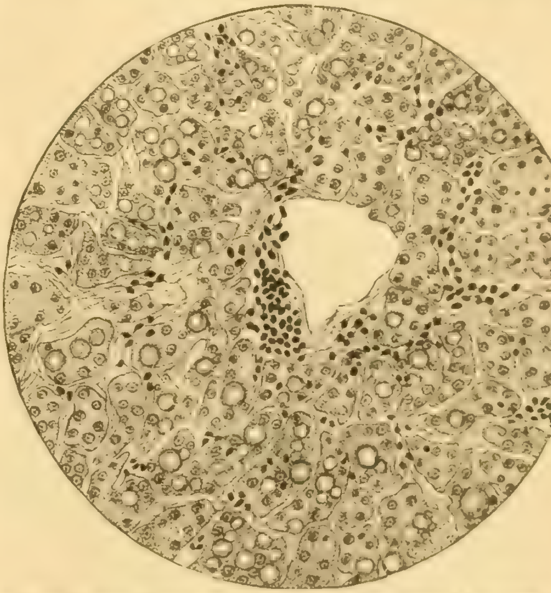

FIG. 4669.—Fatty Infiltration of the Liver Cells, with a Moderate Amount of Small-celled Infiltration, in a Case of Yellow Fever. Material from Havana.

quite free from it,—a stage of congestion antedating that of necrosis and fatty degeneration. According to Cunha, this congestion is limited especially to the portal radicles surrounding the lobules, and is attended with oedema of the intralobular connective tissue. Whether this primary congestion is a constant phenomenon or not, it is evident that in a majority of the examples the liver is found to be anaemic and to present more or less evidence of fatty change in the hepatic cells. This is not, however, a uniform process, but areas of greater or less extent are seen, in which the cells are infiltrated with fat globules (as seen in Fig. 4669), while in other places the cells appear normal. The fatty cells contain one or several fat-globules of varying dimensions and the protoplasm is reduced in quantity according to the extent of the fatty change. The nuclei very often remain intact in the cells infiltrated with fat, but according to Schmidt "a great number of the nuclei also undergo fatty degeneration." Often a circle of normal cells remains about the central vein, while those cells nearer the periphery of the lobule contain numerous fat globules.

In two of the livers brought back from Havana by the Yellow Fever Commission of 1879, in which there was evidence of cirrhosis, Woodward found that in addition to the fatty change described, "an abundant infiltration of cells resembling leucocytes was observed, not merely in the abnormally developed interlobular connective tissue, but also in the parenchyma of the lobules." I have also found an infiltration of leucocytes in two out of four cases which I have recently studied with care. In one, from which Fig. 4669 was drawn, it was attended with the usual fatty change. In the other it is far more pronounced, and the liver-cells to a considerable extent are atrophied and have lost both their nucleus and their protoplasm; indeed a complete necrosis of the cells has taken place (see Fig. 4670). This, however, is quite an exceptional picture, and probably represents a complication rather than an exaggerated degree of an inflammation common to the disease. Schmidt states that he has never observed any evidence of inflammation in the liver of yellow fever.

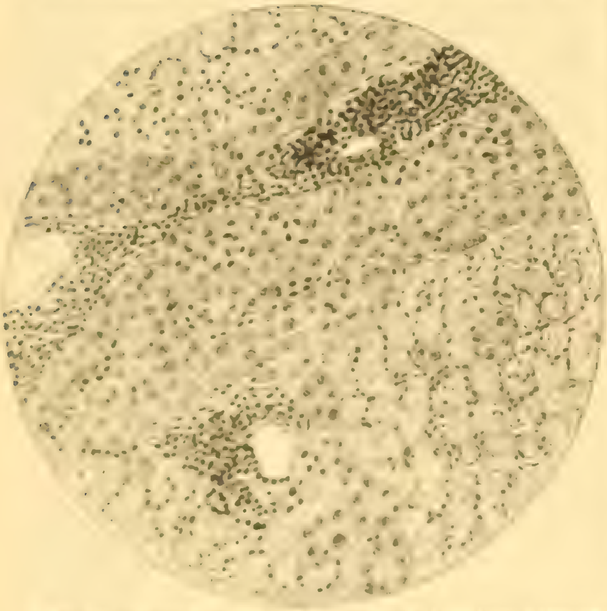

Fig. 4670.—Acute Hepatitis, with Necrosis of the Liver Cells; Leucocyte Infiltration. From a Case of Yellow Fever. Havana, 1887.

The kidneys are also the seat of important pathological changes in the disease under consideration. This consists essentially in a parenchymatous nephritis. Externally no material change is found in the organs. They do not vary greatly from the normal size, and usually are normal in appearance. When the attack has been brief, however, they may be hyperaemic and of a deep red color. Cunha believes that the changes found in the parenchyma of the organ are usually preceded by a stage of congestion; Schmidt agrees with him, and states that he has met with a limited number of cases in which death had occurred during this stage of hyperaemia. Ecchymosed spots and haemorrhagic foci are frequently seen beneath the capsule or in the cortical substance. In the latter situation little globular haemorrhagic points, the size of a pin's head, have been observed, which, upon examination, proved to be the distended capsules of the glomeruli. The change in the renal epithelium consists in a cloudy swelling, followed by fatty degeneration and desquamation. Every grade of change may be seen in the same section, from a slight degree of cloudy swelling to complete disorganization and desquamation of the cells. Whole bundles of tubes may often be seen which have been stripped of their epithelium and are entirely empty. In thin sections the lumen of the tubules is seen in places to be filled with infarctions of variable appearance. Some are homogeneous and translucent, and it may be more or less colored with blood pigment; these are composed of an albuminous material. Other infarctions are formed of the granular débris of the renal epithelium; or we may have a mixture of the granular and albuminous material, in which case the latter forms a matrix in which the granules are imbedded. These infarctions correspond with the casts found in the urine; those of a granular character are most abundant, and in them the granules often have a fatty appearance. There are also accumulations which differ from these in the fact that they are deeply stained by the aniline colors. They seem to be made up of the nuclei of the cells, sometimes intact, although swollen and compressed, more commonly massed together, or broken into irregular fragments. At least this seems to me to be the most probable interpretation of those infarctions which are stained by nuclear staining agents.

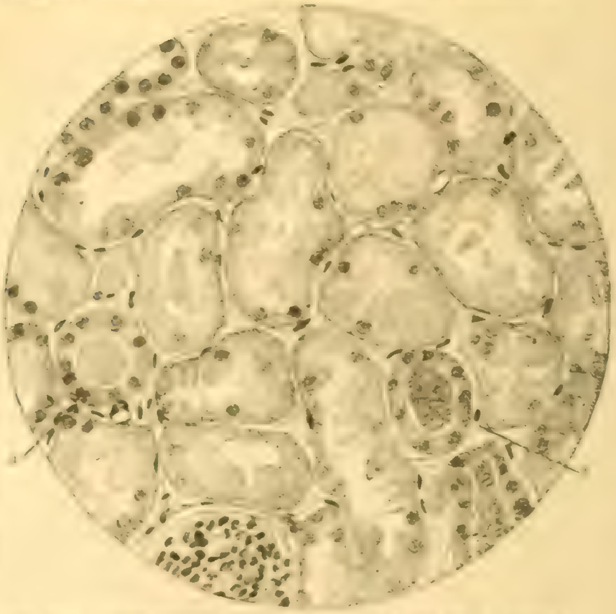

Fig. 4671.—Acute Parenchymatous Nephritis. a, Hyaline; b, granular infarctions. From a case of yellow fever. Havana, 1887.

The suprarenal bodies, according to Schmidt, undergo pathological changes similar to those observed in other organs, "consisting in the infiltration of fat and haemoglobin, derived from the blood and preceded by hyperaemia of the organ. . . . The infiltration or extravasation of haemoglobin absorbed by the cells is greater and more general here than has been observed in any other organ. Almost in every case examined it involved the whole medullary substance, from which it extended into the inner and middle layer, sometimes even into portions of the outer layer of the cortical substance. The degree of this pigmented infiltration is sufficiently great to be always distinguished by its brown color in sections of fresh specimens; in some cases, even, it appears dark brown.

The *spleen* does not undergo any marked alteration in yellow fever.

Treatment.—The unsatisfactory results obtained in the various methods of treatment proposed are shown by the fact that a majority of the physicians, in those parts of the world where yellow fever prevails, who have had an extended experience, agree that active medication is injurious, and have settled upon an expectant or symptomatic treatment, with careful nursing, as giving the most favorable results. Yet the records of the past show that a çertain proportion of the cases recover under all modes of treatment, even the most active and opposed to our present views. The famous Dr. Rush, of Philadelphia, was thoroughly convinced of the advantages of copious bleeding during the first stage of the disease, and ascribed the more favorable results obtained in the epidemic of 1793, as compared with those of 1741, 1747, and 1762, to the more liberal use of the lancet. Venesection was often repeated from five to ten times by Rush and other practitioners of his date, and the amount of blood extracted often exceeded one hundred ounces—one hundred and fifty and even two hundred ounces in some cases. This excessive bleeding was soon abandoned, but the propriety of drawing blood at the outset of the attack was maintained by many practitioners in the United States and the West Indies for many years after the "heroic" treatment of Rush had been abandoned, and the statistics offered in favor of this practice certainly compare favorably with the results obtained at the present day by expectant treatment. Thus Dr. Catel, who was in charge of a military hospital at Martinique, reports that, out of 176 patients treated during the first twenty-four hours by bleeding, 5 only died—a mortality of 1 in 35; of 108 treated on the second day, 11 died, or 1 in 9; and of 143 treated on the third day, 40 died, or 1 in 3. Dr. Lefort, a physician of the same place, also reports that 4 out of 5 of those bled on the first day recovered, and asserts that on the second day bloodletting affords six times less chance of success (La Roche).

The lancet has been entirely abandoned, in accordance with the changed views as to the pathology of febrile affections, but it may be questioned whether in the plethoric new-comers in tropical regions, who furnish so large a quota to the mortality list from yellow fever, a single bleeding at the outset of the attack might not still be practised with benefit.

Emetics were formerly considered an essential part of the antiphlogistic treatment. We speak of them only to condemn them, except in those cases in which at the outset of an attack there is evidence that the stomach contains undigested and fermenting material which is the cause of nausea and distress. In this case a simple emetic may be administered, with the sole object of unloading the stomach.

Purgatives have at all times been considered useful at the outset of an attack of yellow fever, and it is the standard treatment, wherever the disease prevails, to administer a cathartic of some kind as soon as the patient comes under observation. Opinions differ as to the best form of cathartic medicine; some prefer a mercurial, some a saline, and others a full dose of oleum ricini. On account of its prompt and thorough action and the absence of irritating properties, the last-mentioned medicine is a favorite in our own southern cities, in the West Indies, and in Brazil, especially in domestic practice among the creole population. The dose usually given might seem excessive to those who have not seen its favorable action; half a tumblerful, or even more, is the common dose for an adult—two to four fluidounces. Many physicians still prefer a mercurial purge, followed, if necessary, by a saline cathartic, and calomel is the mercurial usually selected. This was formerly given by some practitioners in enormous doses—forty to sixty grains—for its "sedative" effect, and by others in repeated small doses as a "salivant." Dr. Rush introduced the use of mercury as a salivant in the treatment of yellow fever in the epidemic of 1793, and "encouraged by the good effects observed on that occasion from a salivation, he was induced, the next year, to excite it as early as possible in all those cases which did not yield immediately to bleeding and purging. He was delighted to find that it immediately attracted and concentrated in the mouth all the scattered pains of every part of the body, checked nausea and vomiting, and gradually, when it was copious, reduced the pulse—thereby preventing the necessity of further bleeding and purging." He used mercury still more extensively in 1797, and during the memorable epidemic of 1798 a salivation was found by him to be the most certain remedy of any that was used in this fever; for he "did not lose a single patient in whom the mercury acted upon the salivary glands" (La Roche). It is scarcely necessary to remark that this treatment has been entirely abandoned, and when calomel is given to-day it is usually for its cathartic effect, or for its supposed action upon the liver. It may be, however, that it is useful in another way. As we have indicated in discussing the etiology of the disease, it seems extremely probable that it is caused by a microbe whose habitat is in the alimentary canal. If this is in fact the case, the indications are apparent, viz., to keep the *primæ viæ* as nearly empty as possible, so that the multiplication of the specific micro-organism may be restricted by want of pabulum; and also for the purpose of removing the microbe and its poisonous products; second, the administration of germicide and antiseptic remedies, with a view to the destruction of the germ, or at least of restricting its development. In carrying out both of these indications it will be necessary to avoid any measures which would induce gastric or intestinal irritation. For, as we have seen, the gastro-intestinal mucous membrane is in a hyperæmic condition early in the attack, and experience has demonstrated that this condition is aggravated by active medication, or by the presence of food—even the simplest—and that the gravest danger may result from the administration of anything which may add to the irritation of the stomach or intestine, the normal functions of which seem to be arrested as a result of the action of the toxic agent which gives rise to the morbid phenomena. For this reason it is necessary to administer cathartics with great caution, if they seem called for after the second day of the disease. As a rule, it will be best to spare the stomach, and to move the bowels by purgative enemata.

The prevailing opinion that yellow fever is closely allied to the malarial fevers, led many physicians, during the first half of the present century, to prescribe *quinine* in the expectation that it might prove a specific in this disease. This expectation was not fulfilled, but there are still a certain number of experienced physicians who think a full dose at the outset of an attack to be beneficial; others consider it injurious, and as a rule it has been abandoned. There is, however, much evidence in favor of the practice, although the benefits to be derived from it have no doubt been overstated. Dr. Fenner, in his account of the epidemic of 1849, states that the results obtained in the abortive method of treatment by quinine were entirely successful. The dose given was from twenty to thirty grains, with a moderate quantity of morphine or opium, after having unloaded the bowels with a purgative enema. Dr. Fenner says: "This would generally reduce the vascular and nervous excitement completely in the course of a few hours, throw the patient into a profuse perspiration, relieve all pain, and produce sleep." This is certainly a very desirable result, and while to-day it is generally admitted that quinine has no specific action in yellow fever, and that after the first day or two it is liable to do harm by irritating the stomach, the writer is disposed to think that, as an antipyretic and nervous sedative at the outset of the attack, it may often be administered with advantage. This was the conviction of some of our most experienced army surgeons who encountered the disease at Vera Cruz during the Mexican War, and subsequently in New Orleans.

Dr. Anderson, of Mobile, who, with his associate in practice, treated a large number of cases during the epidemic of 1858, says: "The marked and almost magic effect of a large dose of quinine at the outset was so apparent, that they [himself and associate] would have considered it little short of trifling with human life to have adopted any other treatment. They will not deny that there were cases in which it did no good; in fact, in those cases where there was at the commencement decided congestion of the brain, it may sometimes have done harm."

Blair, whose experience was very extensive, and whose treatment seems to have been eminently successful, gave twenty grains of calomel and twenty-five grains of quinine at the outset of an attack, and under certain circumstances repeated the dose several times.

Dr. Porcher, of Charleston, follows Blair's treatment so far as the first dose is concerned, but protests against a repetition of it. We think he is quite right in this, and that his remarks upon treatment are extremely judicious. In some of the new antipyretics and nervous sedatives we have agents which are probably superior to quinine for reducing the temperature and relieving the nervous symptoms. Favorable reports have already been made with reference to some of these. In the epidemic of last year (1887) at Key West, Drs. Porter and [illegible] used antipyrin, as they believe to the advantage of their patients. It has also been prescribed quite extensively in Havana; but I have seen no exact statements as to the results obtained. Nägeli, a German physician practising in Rio Janeiro, has given a very favorable account of results obtained by the use of kairin. According to this author, of 7 cases treated from the beginning, 5 of which were serious (had black vomit) all recovered. The course of the disease was not shortened, but the fever is said to have been controlled. The medicine was administered from the outset in doses of one grain every hour or oftener. This treatment is said to have quickly reduced the temperature—after three or four doses—to 38° (100.4° F.) or lower; at the same time abundant perspiration occurred and the pains were relieved. Doses of one-half a grain were given every hour after the temperature was reduced to the normal to keep it from again mounting. Iced drinks were given, but no food. After the fourth or fifth day it was sometimes necessary to increase the dose to 1½ to 2 grains, in order to control the return of fever. The urinary secretion continued during the use of the remedy, and Nägeli thought that less albumen was present than in similar cases not so treated. As the account of this method of treatment was published in 1884 and we have not heard that it has been adopted to any extent in Rio, the supposition is that, like many other methods, it has not stood the test of fuller experience. In the feeble condition of the heart in the second stage of yellow fever, we should anticipate that the large doses administered—as much as fourteen grains in the twenty-four hours—might be dangerous; but as all of Dr. Nägeli's patients are said to have recovered, we cannot urge this objection.

Many of the French physicians administer bromide of potassium as a nervous sedative, but we anticipate that antipyrin or one of the more recent remedies of this class will be found the most useful in meeting this indication, and for the reduction of temperature. There is no reason to expect, however, that they will prove to be specifics—they simply meet certain indications in the symptomatic treatment of the disease. Some of the physicians in Rio Janeiro have prescribed jaborandi and think well of it, without, however, claiming that it has any specific power. When the skin is hot and dry, it may serve a useful purpose, but it will be necessary to guard against the depressing effects of the remedy. Recently, Dr. Hebersmith, of the Marine Hospital Service, has given the muriate of pilocarpin in several cases, and he thinks with good results. Doses of ⅛ to ¼ grain were given hypodermically and produced profuse perspiration, with reduction of temperature. But as several of his cases were robust persons, and the initial temperature was moderate in all, we are not prepared to admit that recovery was due to the administration of this medicine.

Aconite, digitalis, and veratrum have been tested in the West Indies and elsewhere, in full sedative doses. [illegible] says of these medicines that "the attempts, although sufficiently numerous, have not yet furnished any decided results." After a careful trial of digitalis in doses of two to three grams (30 to 45 minims) of the tincture per dose, the author quoted arrives at the conclusion that in mild cases it seems to cause the fever to fall more quickly, but in intense cases it has not the same power. His general conclusion is, that aconite, digitalis, and veratrum are superior to quinine, and that in moderate doses they are useful in allaying nervous excitement and in moderating to a slight extent the fever. The writer has been in the habit of giving small doses of aconite, in combination with a mild diaphoretic, during the febrile stage of yellow fever, and has thought that some benefit was derived from the treatment, although it must be confessed that this has not been very marked.

Dr. Bemiss, of New Orleans, writes of this class of medicines as follows:

"It is the practice of some physicians to attempt the reduction of fever by large injections of cold water, which are said to prove very efficient antipyretics. Aconite, veratrum, tartrate of antimony, and ipecac are frequently exhibited. A cautious use of one or the other of the first two on this list may prove beneficial, but their injudicious or careless exhibition may do irreparable harm. *We have seen tincture of veratrum produce a most decidedly good effect in mitigating fever, and have often administered it in doses of thirty to sixty drops of the tincture every third or fourth hour.* It is best to give it in solutions of acetate of ammonia or potash.

Dr. Porcher, of Charleston, gives the following mixture as a gentle diuretic and diaphoretic:

℞. Acetate of potash .... ʒ j.
Citrate of potash .... ʒ j.
Morphine .... gr. j.
Camphor water .... ℥ vj.

M. A dessertspoonful to be given every two or three hours as long as there is heat of skin.

Some formula of this kind, which has a gentle sedative and diaphoretic effect, is useful so long as it does not disturb the stomach. Many practitioners refrain from giving any medicine at all, but permit the patient to swallow bits of ice, or small quantities of iced water, at frequent intervals. This we quite approve of, or iced carbonic acid water may be given. Others again give warm drinks to promote perspiration. This is the standard "creole treatment" in New Orleans, and in many parts of the West Indies. As the mortality among this class is small, they are well satisfied with the results obtained, but many strangers unacclimated, who have received the creole treatment die, in spite of the dose of castor oil, the hot pediluvia, and the orange-leaf tea. This treatment with careful nursing is, however, infinitely superior to the active medication of the novice in the treatment of this treacherous disease, for it is very easy to kill yellow fever patients.

Dr. Pardiñas, formerly director of the military hospital at Havana, gave full doses of the tr. ferri chlorid. throughout the disease, and, without claiming for it any specific virtue, he was convinced that the mortality was less under its use than by other methods of treatment with which he was familiar. The director of the Jurujuba Hospital at Rio Janeiro gave me the following formula, which, after trying many different modes of treatment, he has accepted as being, in his opinion, the best:

℞. Perchloride of iron (normal solution) grams iv.
Tincture of [illegible] .... gram 1.
Distilled water .... grams 400.

M. A tablespoonful to be given every hour.

Some physicians in the United States have also used the tincture of the chloride of iron in full doses, and have reported favorable results; but it has not come into general use, even in those places from which the favorable reports have come. In Savannah, during the epidemic of 1854, it was prescribed extensively by Drs. Wildman and Harris. The last-named physician reported that, out of two or three hundred cases treated in this way, he only lost six. La Roche, in commenting upon this report, says: "Unfortunately the remedy, though so advantageous when administered to the sufferers of Savannah, was powerless in the cases of those to whom it owed its celebrity, for both Dr. Wildman and Dr. Harris fell victims to the prevailing epidemic."

Baths of all kinds—hot, cold, tepid, medicated—have been given in yellow fever, and the evidence is varied as to their utility. The most judicious and experienced practitioners are, however, in accord as to the danger of disturbing the patient to the extent demanded by frequent baths, and, as a rule, content themselves with *hot pediluvia* at the outset of the attack, and with sponging the surface with cold water or evaporating lotions to reduce the temperature. Very hot or very cold baths are condemned by Féraud, on the ground that they are likely, even in the first stage of the disease, to produce visceral congestions, to which there is a great tendency in this disease. In the southern part of our own country, and in the West Indies, a *hot mustard foot-bath*, administered at the outset of the attack, is a standard method of treatment. The patient is wrapped in a blanket, and sits with his feet and legs immersed in a bucket of water as hot as he can bear, to which a liberal quantity of mustard has been added. This has a tendency to relieve cerebral congestion and headache, and often produces a free perspiration. It may be repeated several times during the first twenty-four hours. Cold applications to the head and repeated sponging of the hands, arms, and chest with cold water, give comfort to the patient, and are of decided benefit on account of their antipyretic effect. Some practitioners recommend the use of tepid water for sponging the surface; Féraud prefers a mixture of one part of aromatic alcohol with three parts of water; Dr. Peyre Porcher recommends "the assiduous and protracted applications of ice-cold water to the head, hands, and arms, as long as they are abnormally hot." This practice is justified by the results of his treatment, and we think it entirely safe and extremely useful. The knowledge that exposure to cool currents of air, or by removing the bed-covers at night when the weather has suddenly turned cold, is attended with the greatest danger, on account of the visceral congestions—especially of the kidneys—which result from such exposure, has led many physicians to refrain from making use of cold lotions to the surface. The same apprehension has also led to an excessive use of blankets, and the poor patient, who is burning up with fever, is sometimes smothered in blankets and carefully guarded, to prevent him from exposing hand or foot to the air.

Toward the end of the first stage, and throughout the second stage of the disease, this watchfulness to prevent exposure of the body to cool currents of air is very necessary; indeed, it is important at all times if the external temperature is low, and especially at night; but the object in view can be obtained without loading the patient with blankets. He should be lightly covered, but carefully guarded from exposure if the weather is cool. At the same time the body may be sponged under the blanket, and iced water applied to the head, face, hands, and arms, during the febrile stage.

Bérenger-Féraud speaks highly of the use of large enemata of cold water, frequently repeated, as a means of reducing the temperature. He has made extensive use of this mode of treatment, and has never seen any evil results from it.

The use of *sinapisms* and *vesicants* to relieve visceral congestion by revulsion to the surface, is approved by experienced physicians everywhere. We prefer sinapisms, and believe that, as a rule, they will accomplish all that can be expected from a blister. The feeling of weight, distress, or absolute pain in the epigastric region, attended with nausea, which is largely due to the hyperæmia of the gastric mucous membrane, is often notably relieved by the application of a sinapism to the epigastrium. The patient, who has been restless and uncomfortable, will sometimes quickly fall asleep after such an application. In the same way, cerebral congestion and headache may be relieved by revulsives to the extremities, and lumbar pain by the application of a large sinapism to the loins.

The scanty urinary secretion, and often complete suppression, in yellow fever, seems to call for the use of *diuretics*, but unfortunately experience teaches that the most reliable medicines of this class do but little good. The kidneys are best relieved by those means which promote perspiration, and by revulsants applied to the loins. Complete suppression is rarely, if ever, relieved by any plan of treatment. In cases with a hot, dry skin, and scanty urinary secretion, with lumbar pain, indicating congestion of the kidneys, we should expect benefit from the hypodermic administration of the muriate of pilocarpine.

Stimulants are rarely required before the fourth or fifth day, and must be given at first cautiously and in small doses, so as not to disturb the stomach; later, however, they are often absolutely demanded to sustain the feeble heart. During the second stage of the disease, when the pulsations of the heart often do not exceed 40 or 50 to the minute, there is always a tendency to syncope; this is especially manifested during the night, or toward morning, and many a patient, whose condition seemed satisfactory at the evening visit, has been found by his physician dead the next morning. This dangerous period may often be tided over by the use of stimulants. When the stomach is very irritable, a little iced champagne will often answer better than anything else; but perhaps the best form of stimulant is good brandy, given in teaspoonful doses, at intervals of half an hour, more or less, according to circumstances. It should be given ice-cold. Later, milk-punch, English ale, or porter, may be given in liberal quantities, especially to those who are in the habit of using spirits.

Blair, whose opinion in all that relates to this disease is worthy of attention, prefers hock to any other form of stimulant. He says: "Of all cordials the best is Rhenish wine. When of good quality it is retained when everything else is rejected, and it is universally liked by the patients. I have seen the most excellent effects from its use, and have often given it to the extent of two bottles in twenty-four hours. I believe it has saved many lives, and know of no substitute for it."

Medicines administered by the stomach to control vomiting, as a rule, are worse than useless. Minute doses of *morphine*, administered hypodermically, are sometimes useful in checking gastric irritability, but this is a dangerous remedy in yellow fever, and only very small doses are tolerated. Blair has seen stupor, prostration, and complete narcotism follow the administration of one-tenth of a grain. On account of the danger attending its administration, he thinks that it will be more judicious to place it in the *index expurgatorius* of yellow fever. Bemiss, whose opinion is of equal value, says, "Vomiting should be met with epispastics, blisters, ice, and small doses of opium, in combination with cherry-laurel water and sodæ bicarb." An effort should be made to arrest *hæmorrhage* by the use of ergot, the beneficial effects of which are sometimes well-marked. As it is not likely to be absorbed by the stomach, and may cause vomiting, it will be best to administer ergotine hypodermatically.

During *convalescence* the sulphate of quinine, in moderate doses, or citrate of iron and quinine, or the standard preparations of iron and of strychnine, will often be useful as tonics; and ale or porter, or a sound wine in moderate quantities, will be found beneficial.

The *alimentation* in this disease, as in the specific fevers generally, is a matter of prime importance. During the first part of the febrile stage no food is desired, nor is it required. It is best to give nothing in the way of food for the first three or four days of sickness; after this, if the stomach tolerates it, an ounce or two of iced milk or of chicken broth, may be given every two or three hours.

If the stomach is very irritable a smaller quantity at shorter intervals may be given; and it may be best to give the milk in combination with lime-water. If the stomach will not retain this, [illegible]. Do not push it further, but support the strength by nutritive enemata. Even when the stomach is quiet and the patient craves food, it will be necessary to give only liquid nourishment for two or three days, and then to allow nothing but the simplest and most digestible forms of solid food; for there is always danger of a relapse from imprudence in diet, even in the mildest cases.

Before closing this article, the writer ventures to refer briefly to a method of treatment which is still too recent to permit of a definite conclusion as to its value.

This was suggested by me during my recent visit to Havana, and is an attempt to formulate a specific treatment in accordance with our present views of the etiology and pathology of the disease. The intensely acid reaction of the urine and of the vomited matters, and the fact that I have usually found the contents of the intestine [illegible], has led me to believe that a very decidedly alkaline treatment might be beneficial; and, in view of the probability that the specific infectious agent is located in the alimentary canal, I have combined with the alkali selected an antiseptic agent which is known to prevent the development of micro-organisms when present in very minute quantity.

The formula suggested was as follows:

℞ Bicarbonate of soda .... grams 10 (150 grains)
Bichloride of mercury .... centigr. 2 (⅓ grain)
Pure water .... litre 1 (1 quart).

M. Sig.—50 grams (2 tablespoonfuls) every hour; to be given ice-cold.

A letter recently received from my friend Dr. D. M. Burgess, Sanitary Inspector at Havana, gives the following account of the results up to the present date. Dr. Burgess says:

"[illegible] cases have now been treated at Garcini by your alkaline and bichloride method and all have recovered—none subjected to that method have died. Three were treated successfully at another hospital here. Four are to-day receiving the treatment at Garcini, and about an equal number at each of two other institutions."

[illegible]

	Cases.	Cured.	Died.
Dr. [illegible]	[illegible]	[illegible]	[illegible]
Dr. [illegible]	[illegible]	[illegible]	[illegible]
Dr. [illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]

[illegible]

BIBLIOGRAPHY.

[illegible]

George M. Sternberg.

YELLOW SPRINGS. *Location and Post-office.*—Yellow Springs, Greene County, O.

ACCESS.—From Xenia, O., a station on the Pittsburg, Cincinnati & St. Louis Railway, by the Springfield branch of above road to the springs.

ANALYSIS (by Wayne and Locke).—One pint contains (52° F.):

	Grains.
Carbonate of lime	[illegible]
Carbonate of magnesia	[illegible]
Chloride of magnesium	[illegible]
Chloride of sodium	[illegible]
Sulphate of lime	[illegible]
Carbonate of iron	[illegible]
Organic matter	[illegible]
Total	[illegible]

These springs are located in Southwestern Ohio, on the Little Miami River, about sixty-five miles northeast from Cincinnati. The surrounding country is undulating, and affords many beautiful drives to the neighboring towns. Yellow Springs has a population of about 1,400. *G. B. F.*

YELLOW SULPHUR SPRINGS. *Location and Post-office.*—Yellow Sulphur Springs, Montgomery County, Va.

ACCESS.—By carriage from Christiansburg, Va., a station on the Norfolk & Western Railroad, three and one-half miles to the springs.

ANALYSIS (by Professor W. M. Gilham).—One pint contains (58° F.):

	Grains.
Carbonate of magnesia	[illegible]
Carbonate of protoxide of iron	[illegible]
Carbonate of lime	[illegible]
Chloride of potassium	[illegible]
Chloride of sodium	[illegible]
Sulphate of potassa	[illegible]
Sulphate of soda	[illegible]
Sulphate of magnesia	[illegible]
Sulphate of alumina	[illegible]
Sulphate of lime	[illegible]
Phosphate of magnesia	[illegible]
Phosphate of iron	[illegible]
[illegible] matter	[illegible]
Total	[illegible]

Gas.	Cubic inches.
Carbonic acid	[illegible]
Sulphuretted hydrogen	[illegible]

THERAPEUTIC PROPERTIES.—Marked calcic sulphur waters containing an active proportion of cathartic sulphates.

These springs are situated in the southwestern part of Virginia, on the southeastern slope of the Allegheny Mountains, at an altitude of over two thousand feet above sea-level. They are about sixty feet from the summit of the mountain on which they are located, amid beautiful mountain scenery, and possessing a cool, bracing atmosphere during the hottest months. All the modern conveniences for the comfort of visitors are furnished. *George B. Fowler.*

YERBA SANTA. "Consumptive's weed," "Mountain balm," etc. The leaves of *Eryodictyon glutinosum* Benth., Order *Hydrophyllaceæ*. A very pretty evergreen plant, growing on the western side of the United States and in northern Mexico, in gregarious clumps and patches in barren soils and among rocks. It has slender stems branching near the ground and simple above, a metre or more high, bearing numerous alternate or clustered, coriaceous, lanceolate, dentate leaves, five to eight centimetres (2–3 inches) long, and one or two in width. The upper surface of the leaves is smooth and shining, of a dark green color, completely varnished by a copious coating of resin, with which the entire plant abounds. The under surface is covered with a silver-white down, conspicuously netted-veined. Flowers small, something like "forget-me-nots," blue, pretty. Calyx five-parted, corolla funnel-shaped, regular, five-lobed, stamens ten, short, style two-cleft. Fruit, a one-celled capsule, with two placentæ, and one or two dozen seeds. Capsule semi-transparent from saturation with resin (Wellcome, quoted in "Proceedings of the American Pharmaceutical Association," 1876).

The principal constituent of this plant is the resinous compound. It also contains some tannin and a bitter principle. Yerba Santa, as one of its names shows, has a local reputation on the Pacific slope for coughs, colds, bronchitis, and phthisis, a reputation which is shared by many other resinous substances and has some foundation. It is also a pretty good vehicle for the administration of quinine, whose taste, like liquorice or glycyrrhizin, it covers pretty well. Of a fluid extract, three of four cubic centimetres (♏ xlv. ad lx.) may be given for coughs. A syrup as a vehicle for quinine is sometimes prepared.

Allied Plants.—This is a small order of plants, mostly American, containing none of much activity or importance. One or two *Nemophilæ* are cultivated for ornament.

Allied Drugs.—See Grindelia. *W. P. Bolles.*

YOLK-SAC. The vitelline sac, umbilical vesicle, or yolk-sac of man, is a pear-shaped bag of tissue about one-fourth of an inch in diameter, appended to the embryo by a long stalk, which is attached to the intestines of the embryo and runs the length of the umbilical cord, so that the sac lies a short distance from the placental end of the cord, in the space between the amnion and the chorion. These relations are well shown in Fig. 1276 (Vol. III., p. 112). This diminutive sac is always found in the early stages of development, and is said to persist up to birth; the stalk, however, aborts within the cord, and disappears during the first half of gestation.

The yolk-sac, as is shown in the accompanying diagram, is really an appendage of the intestinal canal, and is formed by the extra-embryonic splanchnopleure. During the third week of development, the sac appears very large in proportion to the embryo, but its growth ceases about the fourth week. At first, its connection with the embryo is broad and long (compare Fig. 652, Vol. II., page 144), but as development progresses, the neck becomes more and more constricted and lengthens out (Fig. 4673), so as to form a distinct stalk. Blood-vessels appear very early upon the yolk-sac, developing in the mesoderm of its wall, and forming a network over the sac; these capillaries communicate with two veins, the *omphalo-mesaraicæ*, which carry the blood along the stalk of the sac to the *septum transversum*, and so to the heart of the embryo. The arterial supply probably comes in man, as in the early stages of the rabbit, from small vessels connected with the aorta, but later there are, it is said, larger trunks developed which run out from the dorsal aorta. The arterial trunks disappear very early indeed; consequently in cross-sections of the yolk-stalk we find only the two veins, which pursue a somewhat contorted course. At first the two veins are nearly equal in size, but after the beginning of, say the fourth week, the *left* omphalo-mesaraic vein begins to abort.

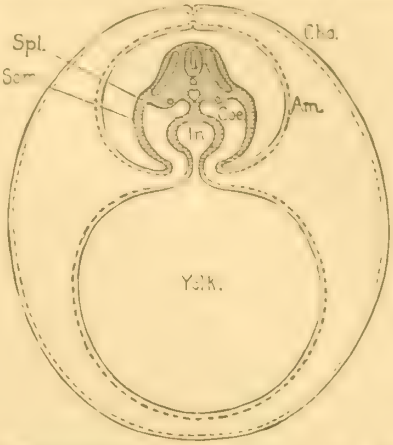

Fig. 4672.—Diagrammatic Cross-section of an Amniote Embryo and Ovum. The embryo is shaded; the extra-embryonic mesoderm is represented by a dotted line. *Som*, somatopleure; *Spl*, splanchnopleure; *Cho*, chorion; *Am*, amnion; *Coe*, coelom; *In*, intestine; *Yolk*, yolk-sac.

The yolk-sac is at first hollow, being lined internally by the entoderm, externally by the mesoderm. In that part of the stalk within the umbilical cord, the cavity disappears. In the vesicle itself the entoderm becomes fatty, and changes into a pavement epithelium, which is also thrown up into vascular villi at certain points (Kölliker).

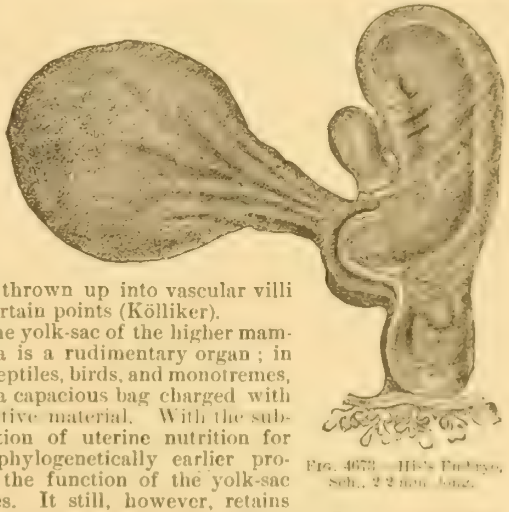

Fig. 4673.—His's Embryo, Sch., 2.2 mm. long.

The yolk-sac of the higher mammalia is a rudimentary organ; in the reptiles, birds, and monotremes, it is a capacious bag charged with nutritive material. With the substitution of uterine nutrition for the phylogenetically earlier process, the function of the yolk-sac ceases. It still, however, retains some yolk in certain cases (Rauber). In the anamniota the somatopleure (chorion) is also continued directly over the yolk-sac, as for instance in sharks, or in other vertebrates, the yolk-sac comprises entoderm (or yolk), mesoderm, and ectoderm. It may happen that the mesoderm fails to develop a coelom over the yolk-sac, and then it is incorrect to say that there are splanchnopleure and somatopleure present. Again, the mesoderm may fail to spread over the whole sac, in which case it is covered in one part by ectoderm lying directly on the yolk. As yet, however, there has been no comprehensive study of these and other modifications of the yolk-sac.

Charles Sedgwick Minot.

YUMA. (For an explanation of the chart and suggestions as to method of using it see article "Climate," Vol. II., pp. 186-194.)

The accompanying chart, obtained from the Chief Signal Office at Washington, represents the climate of the town of Yuma, Arizona, and may be profitably studied in connection with the brief article describing the climate of that Territory, which will be found under the title "Arizona" on page 404 of the first volume of this Handbook.

It is hardly possible to specify, in the case of this chart, which columns contain the data most worthy of attention: all, save perhaps columns J and R, are remarkable. But the extraordinary cloudlessness of the sky, phenomenally low rainfall, great dryness of the atmosphere, great nycthemeral range of temperature, and extremes of high temperature, are the features in the climate of this low-lying Arizona station, which are perhaps those most worthy of attention. *H. R.*

Climate of Yuma, Ariz.—Latitude 32° 45'; Longitude 114° 36'.—Period of Observations, October 1, 1875, to December 31, 1889.—Elevation of Place of Observation above the Sea-level, 139 (approx.) feet.

	A			AA	B		C	D	DD	E		F		G	H
	7 A.M. Degrees	2 P.M. Degrees	9 P.M. Degrees	Degrees	Highest Degrees	Lowest Degrees	Degrees	Degrees		Highest Degrees	Lowest Degrees	Highest Degrees	Lowest Degrees		
January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spring				[illegible]	[illegible]	[illegible]			[illegible]						
Summer				[illegible]	[illegible]	[illegible]			[illegible]						
Autumn				[illegible]	[illegible]	[illegible]			[illegible]						
Winter				[illegible]	[illegible]	[illegible]			[illegible]						
Year				[illegible]	[illegible]	[illegible]			[illegible]						

	J	K	L	M	N	O	R	S
January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	[illegible]	[illegible]	[illegible]	30.6	[illegible]	[illegible]	[illegible]
June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spring	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Summer	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Autumn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Winter	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Year	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ZEDOARY (*Rhizoma Zedoariae* Ph. G.; *Zedoaire longue, Zedoaire ronde,* Codex Med.).

The rhizome of *Curcuma Zedoaria* Roscoe, Order *Zingiberaceae.* This is one of the numerous ginger-like plants which inhabit the warmer parts of Asia, and whose rhizomes or seeds are used as spices or condiments. Zedoary is indigenous in India and China, in which places it is also cultivated. It is introduced and cultivated also in Java and other Pacific islands. The rhizome is the part used, being dug up, washed or scraped, and then sliced and dried: the smaller branches, as is commonly stated, being the "long Zedoary," and the central tubercles or clumps the "round Zedoary." But, according to the French Codex and some other authorities, the latter is the rhizome of a related plant, *C. aromatica* Salisbury. Zedoary comes also occasionally mixed with curcuma. The long variety of Zedoary is of old occurrence in commerce, and was formerly a greater favorite than now, when its place is mostly taken by ginger, cardamom, sweet flag, etc. In this country, indeed, it is well-nigh obsolete, but on the continent of Europe it is still official in most countries, although but very little used.

It figures mostly in external applications as an ingredient of several proprietary liniments and "balsams." The French "*Baume de Fioraventi*" contains Zedoary along with fifteen other resins and spices.

Its composition resembles that of ginger and curcuma, so far as to its taste and flavor being due to essential oil and resin. Like these, too, it contains an abundance of starch.

Allied Plants and Drugs.—See Ginger.

W. P. Bolles.

ZINC. I. General Medicinal Properties of Compounds of Zinc.—Charging the blood with zinc affects nutrition in excess, developing poisonous symptoms, but the action is not as profound as with the majority of the heavy metals, and in medicinal dosage deleterious effects need not be feared. Therapeutically, the constitutional influence shows itself in a tendency—not very strongly pronounced, but still useful—to check spasmodic nervous disorders, such as epilepsy, chorea, hysteria, etc. Indeed, before the rise of bromides into medicinal prominence, zinc was a standard medicine for the relief of epilepsy and hysteria. At present it can only be said that among the heavy metals zinc combines more potency and availability as a constitutional nervine than any other—which is not saying much. Locally, the properties of the zinc compounds differ with the chemistry of the different compounds, mainly according to solubility, the soluble salts being caustic or irritant and astringent, and the insoluble compounds operating as absorbent, soothing, healing, and disinfectant dressings. Internally, the soluble compounds in moderate dosage determine prompt and thorough vomiting, after the manner of copper salts, though with less severity of action. In large doses they are corrosive or irritant poisons, according to the activity of the individual compound. The insoluble compounds in small dose allay gastric and intestinal irritability, but in large dose, probably through chemical conversion, may nauseate, and even vomit. Zinc-compounds are disinfectant, the soluble salts, especially the chloride, notably so, and since they do not stain they are the most generally available of metallic salts for the purpose.

The *therapeutics* of zinc consist of the following applications: *constitutionally*, as a medicine of second or third rate power to control spasmodic nervous disease; *in the stomach*, to allay pain or nausea, for which purpose an insoluble compound is commonly selected; *in the bowels*, to control diarrhœa, especially when the affection seems a reflex of nervous irritation rather than the expression of a catarrh; and, *externally*, the soluble compounds, to cauterize, or to perform the usual functions of a metallic astringent-irritant in the way of determining absorption of granulation-tissue, and abating catarrh; and the insoluble preparations to act as soothing, healing, or, applied dry, absorbent and disinfectant dressings. Solutions of the soluble salts are also available as efficient disinfectants of their kind for wounds, fabrics, floors, and all non-metallic receptacles.

II. THE MEDICINALLY-USED COMPOUNDS OF ZINC.—These are the *oxide*, *carbonate*, *chloride*, *bromide*, *iodide*, *sulphate*, *acetate*, *valerianate*, and *phosphide*, and, although not officinal, the *nitrate* and *oleate*.

Zinc Oxide (ZnO).—Zinc oxide is officinal in the U. S. Pharmacopœia as *Zinci Oxidum*, Oxide of Zinc. It is a "soft, pale yellowish, nearly white powder, permanent in the air, odorless and tasteless, insoluble in water or alcohol, but soluble in acids without effervescence (absence of carbonate). When strongly heated, the oxide assumes a deep lemon-yellow color, but turns nearly white again on cooling" (U. S. Ph.). Oxide of zinc is a commercial article, and impure and even fraudulent specimens are not uncommon. Oxide of zinc is the principal insoluble zinc compound. It may be used, given internally, for the constitutional effect of zinc, or to allay vomiting or diarrhœa; dose, from 0.06 to 0.30 Gm. (one to five grains), several times a day, in powder or pill. Externally, zinc oxide may be used, alone or mixed with powdered starches or gums, as an absorbent powder-dressing to excoriations and sores, or, in ointment, as a soothing and healing application, for which purpose it is very efficient. There is an officinal ointment, *Unguentum Zinci Oxidi*, Ointment of Oxide of Zinc, consisting of twenty per cent. of the oxide in benzoinated lard, which may be applied in full strength to sores or eruptions.

Zinc Carbonate.—Normal zinc carbonate occurs in the mineral *zinc spar* or *calamine*, which was formerly officinal in the U. S. Pharmacopœia as a medicine, but was dropped, because of its impurities, in the revision of the Pharmacopœia of 1860. In its place is officinal, now, the mixture of carbonates that results from precipitating a boiling solution of zinc sulphate by sodic carbonate. Such precipitate is entitled *Zinci Carbonas Præcipitatus*, Precipitated Carbonate of Zinc, and is assigned the formula $(ZnCO_3)_2 . 3\,Zn(OH)_2$. Precipitated zinc carbonate is "a white, impalpable powder, permanent in the air, odorless and tasteless, insoluble in water or alcohol, but soluble in acids with copious effervescence. When strongly heated, the salt loses water and carbonic acid gas, and leaves a residue of oxide of zinc" (U. S. Ph.). Zinc carbonate is substantially a duplicate of the oxide in medicinal properties, but its use is commonly confined to external application as an absorbent powder.

Zinc Chloride ($ZnCl_2$).—The salt, often commonly called *butter of zinc*, is officinal in the U. S. Pharmacopœia as *Zinci Chloridum*, Chloride of Zinc. It is "a white, crystalline powder, or white, opaque pieces, very deliquescent, odorless, having a very caustic saline and metallic taste, and an acid reaction. The salt is very soluble in water and in alcohol, forming a clear, or only faintly opalescent, liquid. This opalescence is removed by the addition of a few drops of hydrochloric acid When heated to about 115° C. (239° F.), the salt melts, yielding a clear liquid which, on cooling, congeals to a white or grayish-white solid. At a higher temperature it is partially volatilized and decomposed" (U. S. Ph.). The chloride is the most active of the zinc salts, being highly corrosive and antiseptic, both. It has little effect on the sound skin, but upon a raw surface or mucous membrane it disorganizes tissues, forming a white, tough slough. The action, though powerful, is not diffuse, so that it can be quite exactly regulated in area and depth. The slough remains odorless during its attachment, and, when finally cast off, as happens in a week or ten days, exposes an underlying surface presenting clear, healthy granulations, which rapidly proceed to cicatrization. Chloride of zinc thus makes an excellent escharotic, combining the features of being powerful, yet manageable, of disinfecting its own slough, of determining kindly healing of the resulting ulcer, and of being free from danger of producing constitutional poisoning. Its operation is, however, very painful. In solution, zinc chloride is a standard disinfectant, but, if strong, acts upon metallic surfaces. Internally, it is a corrosive or irritant poison, according to concentration.

For use as a caustic, patent lint may be soaked in a concentrated solution of the salt, dried, and then cut—with an old, worthless pair of scissors—into proper size and applied to the part, which, if covered with skin, must first have the epithelium removed by blistering. Much more convenient, however, is the plan of making the chloride into a paste with flour and water. Such paste can be applied moist, or may be dried and cut into pointed rods, which are then available for thrusting into any large mass requiring destruction, such as a cancerous tumor. This paste was devised by a Dr. Canquoin, of Paris, and often goes by his name. It is made by rapid admixture of zinc chloride and wheat-flour with a very little water—a few drops only to the ounce of paste. The strength in zinc salt will range from fifteen to thirty per cent., according to the character of the tissue requiring destruction.

As a disinfectant, zinc chloride can be prescribed in the officinal *Liquor Zinci Chloridi*, Solution of Chloride of Zinc. This is "an aqueous solution of chloride of zinc, containing about fifty per cent. of the salt." It is made directly from the metal by the action of hydrochloric acid, the resulting solution being purified from contaminating iron by a special procedure, and brought to standard strength by distilled water. The solution is "a clear, colorless liquid, odorless, having a very astringent, sweetish taste, and an acid reaction. Sp. gr. 1.555" (U. S. Ph.). In its pharmacopœial strength, this solution is entirely too strong for direct application, being, indeed, corrosive. As a general disinfectant, it should be diluted to three per cent. strength, and as a lotion for wound-surfaces or ulcers to one per cent. It has the merits of being deodorant and disinfectant, while at the same time it has no smell, does not stain, and, in the dilution enjoined, does not attack fabrics, or even practically injure metallic receptacles.

Zinc Bromide ($ZnBr_2$).—Zinc bromide is officinal in the U. S. Pharmacopœia as *Zinci Bromidum*, Bromide of Zinc. It is a "white, or nearly white, granular powder, very deliquescent, odorless, having a sharp saline and metallic taste, and a neutral reaction. Very soluble in water and in alcohol. When strongly heated it fuses, and, at a higher temperature, it is volatilized with partial decomposition" (U. S. Ph.). Because of its ready deliquescence, the salt should be kept in small glass-stoppered bottles. Zinc bromide closely resembles the chloride in general properties, being deliquescent and highly irritant. Its officinal recognition is, however, not for its duplicature of the chloride in uses, but for its internal employment in nervous disease, with the notion of getting the combined antispasmodic effect of zinc and a bromide. But in the small dosage which the character of the salt ceiving the quantity of bromine ingested is practically insignificant. The salt is given in doses of from 0.15 to 0.30 Gm. (two and a half to five grains), in syrupy solution.

Zinc Iodide (ZnI_2).—Zinc iodide is official in the U. S. Pharmacopœia as *Zinci Iodidum*, Iodide of Zinc. It is "a white, or nearly white, granular powder, very deliquescent, odorless, having a sharp saline and metallic taste and a neutral reaction. Very soluble in water and in alcohol. When strongly heated, it melts, and, at a higher temperature, it is sublimed with partial decomposition" (U. S. Ph.). Zinc iodide, like the bromide, resembles the chloride in qualities; but, like the bromide, is suggested for the purpose of getting the effects of the iodine salts along with those of zinc, in constitutional medication. But again the necessarily small dosage defeats the purpose. The salt is given in doses of from 0.10 to 0.20 Gm. (one and a half to three grains) in syrup. Locally, the iodide has been applied for the general purposes of the metallic astringents, in solutions ranging in strength from the one-fifth of one per cent. to six per cent., or as a twelve per cent. ointment.

Zinc Sulphate ($ZnSO_4 + 7H_2O$).—Zinc sulphate is official in the U. S. Pharmacopœia as *Zinci Sulphas*, Sulphate of Zinc. It is in "colorless, transparent, small, columnar, rhombic prisms, or acicular needles, slowly efflorescing in dry air, odorless, having a sharp saline, nauseous, and metallic taste, and an acid reaction. Soluble in 0.6 part of water at 15° C. (59° F.), and in 0.3 part of boiling water; insoluble in alcohol. When strongly heated, the salt melts, gradually loses water, and, at a higher temperature, it is decomposed, with evolution of sulphurous vapors" (U. S. Ph.). Zinc sulphate is the sulphate whose commercial impure variety is called white vitriol. The pure quality, official as above, is in the small crystals described, which look not unlike those of Epsom salt. Zinc sulphate is decomposed by alkalies and their carbonates, hydrosulphates, lime-water, soluble lead salts, and vegetable astringents. By heating, it can be made to part with its water of crystallization, forming what is called *dried zinc sulphate*.

Zinc sulphate is an irritant astringent, and, in the dried form, even caustic, though less powerfully so than the chloride. Internally, in moderate dose, it is emetic, in excessive quantity an irritant poison, though again less potent than the chloride. The salt is a favorite metallic astringent, being milder than copper or silver salts, as less irritating, and without staining property. It has thus a wide range of applicability, but yet, where a powerful action is wanted, it is distinctly inferior to nitrate of silver, or sulphate of copper. The crystals are too small to permit the salt to be used in solid form; it is therefore used mostly in solution, the strength ranging from the one-fifth of one per cent. to about four per cent. Dried zinc sulphate has been employed as a caustic, made into paste with one-eighth part of glycerin, or into ointment with one-fourth part of lard. Internally, the salt—preferably in pill form—may be given for the constitutional effects of zinc, in doses of from 0.015 to 0.06 Gm. (one-fourth to one grain), several times a day, or as an emetic in doses of from 1.00 to 2.00 Gm. (fifteen to thirty grains).

Zinc Acetate ($Zn(C_2H_3O_2)_2 + 3H_2O$).—Zinc acetate is official in the U. S. Pharmacopœia as *Zinci Acetas*, Acetate of Zinc. It is in "soft, white, micaceous or pearly, six-sided tablets or scales, somewhat efflorescent in dry air, having a faintly acetous odor, a sharp metallic taste, and a slightly acid reaction. Soluble in 3 parts of water and in 30 parts of alcohol at 15° C. (59° F.); in 1.5 part of boiling water, and in 3 parts of boiling alcohol. When strongly heated, the salt melts, and at a higher temperature it is decomposed with evolution of inflammable vapors, a residue of oxide of zinc being finally left" (U. S. Ph.).

Zinc acetate is practically a duplicate in its effects of the sulphate; but its use has been rather restricted by custom to local application for the purposes of the metallic astringents. Solutions may be employed of the same strength as of the sulphate.

Zinc Valerianate ($Zn(C_5H_9O_2)_2 + H_2O$).—This salt is official in the U. S. Pharmacopœia as *Zinci Valerianas*, Valerianate of Zinc. It is in "soft, white, pearly scales, permanent in the air, having a faint odor of valerianic acid, a sweet, afterward styptic and metallic taste, and an acid reaction. Soluble in 100 parts of water and in 40 parts of alcohol at 15° C. (59° F.), both solutions becoming turbid on boiling. When heated, the salt melts; at a higher temperature it gives off white, inflammable vapors, and finally leaves a residue of oxide of zinc" (U. S. Ph.). From its comparative insolubility, zinc valerianate is locally less active in every way than the salts typified by the chloride and sulphate. Its place in medicine rests upon the idea of combining in one drug the antispasmodic virtues of zinc and valerian; but since the effects of zinc are feeble at best, and valerianic acid is probably not the active principle of valerian root, there is little ground on which to rest a valid claim for the salt's efficacy. Zinc valerianate has also the positive disadvantages of disagreeable smell and taste and costliness. The salt has been given in doses of from 0.06 to 0.12 Gm. (one to two grains), several times a day, best in pill.

Zinc Phosphide (Zn_3P_2).—This salt, being of value solely as a means of giving phosphorus, has been described under the title Phosphorus.

Zinc Nitrate ($Zn(NO_3)_2 + 6H_2O$).—Zinc nitrate forms by the direct action of nitric acid upon metallic zinc. It occurs in colorless prismatic crystals which are soluble in water and alcohol, and are very deliquescent. The salt is fusible, and has been employed, although it is unofficial, in the form of sticks of the fused substance cast in paper moulds, for application to sores and ulcers. The action is caustic and healing, after the manner of silver nitrate. Sticks of zinc nitrate must be kept dry in well-stoppered bottles, else they will be destroyed by deliquescence of the salt.

Zinc Oleate.—An oleate of zinc is obtainable in the form of a fine, soapy feeling powder, of a pearl color. This powder proves to be a serviceable bland absorbent and detergent for local dusting upon the skin.

Edward Curtis.

ZYMOTIC DISEASES. It is somewhat remarkable that, with the evidences of organic changes constantly present on every side, the far-reaching observations and deep scrutiny of men of the past into the processes of nature should have failed to discover, or, at least, adequately realize what to us to-day seems so ordinary a process as that of fermentation, as also the causes underlying it. But observation had not failed to mark and, in some measure, accurately to note its results; for these, as seen in the leaven of bread and in the changes which the juice of the grape undergoes, have been known since the beginnings of history. Manifestly, therefore, it has been the means for accurate study and observation that has been wanting. A century ago, when one of the pioneers of chemistry made this memorable statement, "He that understands the nature of ferments and fermentations shall probably be much better able than he that ignores them to give a fair account of divers phenomena of certain diseases (as well fevers as others) which will, perhaps, never be understood without an insight into the doctrine of fermentations," it was beginning to be perceived that these fermentations, resulting in a transformation of the constituents of a substance, were due to processes which, while chemical in their nature, involved the agency of external influences which, as the oxygen of the air, acted directly upon the organic substances affected. Further for many years discovery did not go, until, as in the instance of the yeast plant, it was noticed that the chemical changes in beer wort were coincident with the free growth and multiplication of the cells of the plant. That the presence of the plant was the condition of this chemical change was for a long time slow to be believed; and even as late as 1882 Dr. Angus Smith inclined to the belief that nitrification may go on to some extent apart from the presence of microbes. The numerous investigations of the school, with Pasteur at its head, which adopted for its motto *omnis cellula a cellula*, have now for many years fully elucidated this "doctrine of ferments," and have thereby given rise to the new science of bacteriology.

But nothing better illustrates how difficult it is for the scientific mind to keep more than one idea before it than does this, for hardly had the bacterial theory gained a permanent basis, than the chemical side of fermentation began to be thrust into the background. For a time it was the microbe that was being sought rather than its effects; and not until the attempt to connect in every case a distinct species of microbe with a separate fermentative or pathological process had proved unsatisfactory, was it fully realized that, in the etiology and progress of a zymotic disease we have to hold a strict account with the elaborated products due to bacterial growth and multiplication. Said Dujardin-Beaumetz neatly, in a recent lecture on Prophylactic Hygiene, "Prophylaxis has entered upon a new scientific route, and the basis of modern preventive medicine is two great discoveries—that of the pathogenic micro-organisms on the one hand, and on the other, of the incessant production by the economy of toxic alkaloids, ptomaines, and leucomaines."

With the great improvements in the microscope, with the development of the theory of cell-growth in plants and animals, and with a knowledge of the cell-constituents of the blood and animal tissues, it was to be expected that observers should surmise that, as lower forms of cell-life were found to develop and multiply outside the body, so they might similarly do in the blood itself. On such a theory the formation of abscesses and the secretion of pus within the body might be explained. In such a direction Jenner's discovery of the protective value of the inoculation of vaccine lymph seemed to point; but systematic experimentation was needed along exact scientific lines before the broad facts underlying these phenomena could be properly understood. Before all experimenters must be placed Pasteur, as the one to cause this world to rise out of chaos. With his chemical class he undertook the study of the production of the alcohols, and by research disproved the generally received theory of Liebig, that such was due to fermentations dependent on albuminoid substances which became altered during the process. Pasteur found that the degree and kind of fermentation depended exactly upon a bacterium of a particular kind, thereby elaborating those remarkable conclusions as to the *aërobies* and *anaërobies*, which went far to explain the hitherto supposedly chemical nature of nitrification as being due instead to the action of microbes.

But these discoveries were soon to be extended in the scope of their application. Davaine had found certain rod-like bodies in the blood of animals dead from anthrax, and imagined that they played a part similar to the rods in Pasteur's alcoholic fermentations; and thereafter Pasteur was commissioned by the French government to investigate this disease, which was causing annually immense losses of both cattle and sheep. The zymotic nature of the fermentative action, both in the production of alcohols and in splenic disease, had been generally accepted for several years, when Tomasi-Crudeli aroused anew the interest in the new science by the publication of experiments pointing toward the discovery of the cause of malaria or intermittent fever. Other experimenters questioned the accuracy of these observations, seemingly lately confirmed by Cohn and his assistants. But an event of greater interest shortly after took place, when Koch published his experiments, which demonstrated that tuberculosis was a zymotic disease, having its origin not in tubercles of various appearance, but in a microbe, which in its growth and multiplication sets up the inflammatory action upon which the formation of tubercles depends. Said Professor E. J. Barker, F.R.C.S., recently, in his lectures on Tubercular Joint Disease: "But though all these facts seemed to point very clearly to the identity of scrofula and tuberculosis, it was not until the discovery of the bacillus tuberculosis, and its demonstration in the initial lesions of these two affections, that positive proof was actually forthcoming. Almost at the same time, Koch and Baumgarten pointed out that in typical tubercular and scrofulous nodules this organism could invariably be demonstrated by different methods of preparation. These researches were soon supported by a whole army of bacteriologists, both at home and abroad."

To have been able to explain the etiology of a disease so ubiquitous as consumption, was to give to bacteriology a practical value and impetus which must have long been wanting, had these discoveries been limited to anthrax and the vinous ferments. Since then the study has advanced with enormous strides, and its influence dominates the whole realm of medicine. Surgery has been revolutionized by Listerism, and asepticism has become the goal and condition of successful surgery. Therapeutics bases her hopes of progress largely upon the doctrine of ferments, and preventive medicine has as her battle-cry cleanliness as opposed to putrefactions, fermentations, sapræmias, and septicæmias. To state that in the latest tables by Cornil and Babes some one hundred and thirty species of bacteria have been described, is but to indicate the progress in the study of micro-organisms. We have only to recall the fact that rouget, chicken-cholera, enteric fever, Asiatic cholera, glanders, and many other diseases have been proved in all probability to be due to specific microbes, in order to understand what advances have in recent years been made in the etiology of disease.

But it were contrary to all experience to suppose that these demonstrations could long prove sufficient to satisfy the physician, who has chiefly to deal with effects; to know these facts could be of but little moment, should he not likewise be informed regarding the operations of micro-organisms. To the agriculturist a botanical classification has but little significance, if he knows nothing of those conditions which make the development of plant life luxuriant, in the case of his grains and grasses on the one hand, or which can minimize the growth of injurious plants and weeds, on the other. In fact, the life-history of micro-organisms must be, equally with the discovery of species, the work of the bacteriologist, but especially of him who would investigate zymotic diseases.

This the discerning mind of Pasteur early realized, and as early as 1881 he isolated and cultivated the microbe of chicken cholera, discovered by Peroncito in 1878, and applied its attenuated virus to the prevention of outbreaks of the disease. He had already indicated the distinctions between *aërobies* and *anaërobies*, and shown how, by alterations made in the culture medium, development might be aided or retarded. Such investigations led Davaine to conclude that the bacillus of cholera spored or fruited in the same manner as many known forms of cryptogamia. Then came the stage of the division of bacteria into sporing forms and non-sporing forms, and of the study of the conditions favoring sporulation. Temperature was found to be the factor whose influence, next to nutriment, was of importance in this development.

This was first investigated most thoroughly in the instance of charbon, when it was found that 35° C. (95° F.) proved most favorable to the growth and development of spores; that a temperature of 42° to 43° C. (107.6 to 108.4° F.) favored rapid growth of the mycelium, which was checked at a temperature two degrees higher still, while five degrees higher yet finally destroyed the plant.

Apart, however, from the mere fact of the discovery of the cause of tuberculosis, the next greatest step in advance in the study of micro-organisms was that made by Koch, who in his published investigations, in 1882, illustrated his methods of solid cultures. He then used gelatinized blood-serum, while to-day potato, gelatine, peptones, and agar-agar are constantly utilized as culture-media. The behavior of micro-organisms in their growth on these cultures, both as to their action on the constituent elements of the culture material and as to their macroscopic appearances as colonies and mycelial growths, is one of our chief means of differentiating between species and of obtaining pure cultures.

Such then, briefly summarized, are the steps by which ed have attained to our present knowledge regarding bacteria, and the agencies which it is now believed lie at the origin of zymotic diseases. How far any really distinctive classification of micro-organisms can at present be made it would be difficult to say; but a division into sporing and non-sporing forms will doubtless hold, since upon this quality some of the most important influences of those bacteria which cause disease depend.

We have already referred, in the beginning of this section, to the processes which [illegible] entered into the processes by which sugars became transformed into alcohol or acetic acid, and by which putrefaction of organic substances takes place in the soil. As to very distinct from these processes are those which go on in the growth and multiplication of microbes in the fluids of the body or in its tissues, except in the fact that, inasmuch as their presence is foreign to the well-being of the animal organism, their multiplication is opposed by the normal processes of the body; and that it is only when the resistance of the system is unequal to the task of destruction that the multiplication of these organisms proceeds to such an extent in the system as to cause disease. In every instance the growth and development of these micro-organisms of that zymosis give rise to products which belong to the normal physiological processes of vegetable plant life. The products of these physiological processes of bacteria have without doubt never been studied by Nencki, Gautier, and Brieger in so thorough a fashion, that some doubt suggest the multiplication of microbes in the human system produces such severe effects through their influences on the physical conditions of the person affected, has become possible. Says Dujardin-Beaumetz: "I shall show you, then, that the gastric disturbances—indigestion, and various intestinal troubles, and even the fatal phenomena which may supervene upon the ingestion of putrid foods—owe to their sole cause the presence, in greater or less quantity, in the digestive canal, of the alkaloids which I have just mentioned."

In this rapid review of the scientific basis upon which the theory of zymosis has been built up, it is made manifest that, as the science of "microbie," as Pasteur has recently named it, is but little more than well begun, so we must expect that as it advances many new facts will be learned regarding those diseases now called zymotic, which may cause us to some degree to modify our present views regarding them; while to the list of diseases now known to be of bacterial origin we may expect to add many more whose causation is now a matter of doubt.

Accepting zymosis as a fact, it becomes of importance to determine, with as much accuracy as possible, what those diseases are which with our present knowledge may fairly be classed among zymotic diseases. Until very recently, much discussion has taken place on the distinctions to be made between miasmata, infections, contagions, etc.; but with our present knowledge of zymoses it is easy to understand why no common basis for a classification could be accepted, or, indeed, be possible. Infections and poisons have similarly been confounded as a result of evidence gained from pathological phenomena. Bouchard has, however, clearly made the distinction between these, when he says that infection is produced by a particular poison, differing from ordinary poisons in that it reproduces itself indefinitely; he, in fact, regards it as a living body which multiplies. Again, Dujardin-Beaumetz says: "we shall . . . reserve the name of infection to designate the penetration of the economy by a living principle, capable of multiplying itself in the organism, i.e., of microbiotic origin."

According to this, Bouchard's distinction of a miasm as being an infectious substance which multiplies itself outside the organism can hardly be considered as the basis of a classification; many infectious, and hitherto considered miasmatic, are found to be capable, at least under artificial conditions, of multiplication outside the body. Of this fact, the bacillus of tubercle may be given as an illustration. Says again Dujardin-Beaumetz: "It seems to me that to-day, thanks to the incessant progress of microbiology, we may modify these divisions, and say with Bouchard, that every infectious disease is a function of microbes; not that science is in possession of the exact knowledge of all the pathogenic microbes, but the absolute similarity which exists between the microbe-diseases and the virulent diseases of which the microbe is unknown, is such that we may affirm that the cause which presides over these affections is the same in kind. It will not do to conclude from this affirmation that the infectious diseases—microbe-diseases—are all contagious, and you readily understand that there may be microbe diseases which are not contagious, or, at least, whose contagion is operative only under conditions which never exist in the ordinary or normal state." Clearly, then, we have to include under zymotic diseases those which, in their history, are found to have a period of incubation, whether or not their specific microbe has been, up to the present time, isolated; and which, during this prodromal period, produce such effects upon the animal economy as are known to be produced, in varying degrees, by those infections whose life-history has been investigated, and whose pathological phenomena are now well recognized, if not wholly understood.

Here, again, notable variations are observed, based, however, largely upon the special qualities of the disease, first as to those parts where its development primarily becomes possible, and second, as to the rapidity of its development within the system; or, in other words, according to whether the disease produces acute and rapidly developing symptoms, as in cholera and scarlatina on the one hand, or lepra and tuberculosis on the other. Yet clearly we have here variations not in kind but in characteristics of the development of the zymosis, since we know that, in such diseases as typhoid fever, the progress of its development varies greatly both according apparently to the amount of the virus received into the system, and, again, according to the degree of resistance which the system makes to its development, depending not alone upon the vital resistance of the constitution to the disease, but upon the favorable nature of the blood or culture medium to the multiplication of the specific microbe. Probably no better illustration can be given of this latter point than that of the negro of the Southern rice plantations. Living constantly in a malarial atmosphere, he is exposed with impunity to an infection which quickly affects a person not acclimated; while it is said that the American negro, returning to Liberia, becomes a ready prey to the deadly fevers of the African coast. From these statements regarding the progress of the disease in the system after the inoculation of any virus, it is evident that we cannot in any exact way fix the number of days at which after its invasion markedly acute symptoms will take place; and clinical experience has been forced to fix a by no means exact number of days at which invasion after inoculation takes place. For the same reason, viz., the resistance of the system to the poison, the point at which its inoculation takes place—whether by the digestive tract, the respiratory organs, abrasions of the skin, the vaginal mucous membrane, or the veins of the uterus—it will be plain that the intensity of the symptoms may vary indefinitely. It may further be pointed out that the qualities of the specific microbes of any disease, as regards the normal rapidity of their multiplication, will govern in a large degree the rapidity of the initial symptoms of the disease as well as the duration of the zymosis. Thus, taking the two diseases, cholera, whether Asiatic or cholera nostras, and enteric fever, we find the first short in its incubative period, intense in its symptoms, and, where not fatal, brief in the duration of its later stages; on the other hand, in typhoid fever we have a frequently very long incubative period, with an advancing severity of symptoms, and a frequently very protracted period, even months, before recovery takes place. Similarly, in carcinoma and tuberculosis we have even greater differences in the various stages of their development and progress.

What the special reasons are which cause these variations in zymotic diseases have not as yet been very definitely determined, but it is probable that they depend primarily upon the properties pertaining to the individual classes of these micro-organisms, *e.g.*, the micrococci and the bacilli, and, secondly, upon the suitability of the culture medium for the free development of any particular organism. Further, that the various organisms are capable of the development of special properties in certain directions, under variations of the culture media and of their environment, seems from various facts to have been proved beyond doubt. Thus typhoid has not hitherto been transmitted to animals, unless, indeed, certain recent experiments of Vaughan may have proved that dogs are not wholly refractory to it. Again, hares and guinea-pigs, readily inoculable with true anthrax, prove refractory to *charbon symptomatique.* Further, Gamaleïa, of Odessa, has recently shown, in a paper presented by Pasteur before the French Academy of Sciences, that the spirillum of cholera acquires an increasing virulence in its transmission from pigeon to pigeon. Finally, according to Loeffler, the individual resistance of rats to charbon inoculation varies, apparently, according to the physical resistance of the animal from day to day, due, it must be supposed, to atmospheric conditions or environment, or more probably, as suggested by Feser, to the character of the food upon which the animal had for some days previously been fed.

These latter facts have an extremely important bearing upon the whole question, not only of prophylaxis, but also of the treatment of the disease as regards its probable termination. We are aware that the probabilities of a favorable termination, in cases of scarlatina and diphtheria, for example, can, other things being equal, be in a very large degree measured by the hygienic and sanitary conditions under which patients are placed. Russell, of Glasgow, and Carnelley, of Dundee, have shown, from the mortality statistics of these two cities, that the rate per 1,000 of population progresses regularly as the number of rooms of a house decreases from four or five to two and one; while we are personally aware, in reports from time to time received from frontier settlements, of instances where large families crowded into cabins of one or two rooms, and having poor food and limited medical aid and comforts, have had every child carried off by diphtheria, while grown persons have, in too many instances, met with a similar fate.

In the foregoing paragraphs, we have endeavored to set forth the nature of the phenomena which may be said to belong to all zymotic diseases, rather than to discuss the clinical features and pathological peculiarities which serve to distinguish them one from the other.

In the present state of our knowledge, it is perhaps scarcely advisable to attempt any definite classification of these diseases, since such classification must vary according to the standpoint from which they are viewed, and, moreover, because each disease has some characteristics which would entitle it to a place in different classes. For instance, diphtheria might, according to some, be kept out of the class having symptoms of a constitutional character; according to others, it would be classed along with other septicæmias; while again, inasmuch as it may develop a rash, it might fairly be placed under the exanthems. Again, were we to make a class of those diseases in which the virus is apparently taken into the system by the digestive tract, *e.g.*, cholera, enteric fever, and diarrhœa, we could scarcely avoid classing diphtheria with them, since it is well known that milk and water are vehicles by which it is introduced into the system. For practical purposes, however, it seems desirable that, whatever may prove in the future to be the preferable basis of classification, there should be some arbitrary division of zymotic diseases. From the standpoint of prophylaxis, there are some leading points which may fairly be adopted as a basis for the classification of those diseases which are most prevalent, and whose characters are therefore best understood. Thus, under the heading of *Soil Diseases*, we may place (*a*) the indigenous fevers, as intermittent, congestive fever, mountain fever, swamp fever, coast fever, yellow fever, etc., since, in a very special sense, they are associated with the emanations from a decomposing organic soil of vegetable origin; (*b*) choleraic diseases, as Asiatic cholera, cholera nostras, cholera morbus, cholera infantum, dysentery, diarrhœa, etc.; for, while some of these are associated to some degree with decomposing animal matters, it is still true that the drainage from soils into rivers and streams, the water of shallow bays, etc., are peculiarly prone to produce these troubles. Again, we have *Filth and Crowd Diseases, par excellence*, under which we would place (*a*) typhus, and ship fever, dengue, famine fever, prison fever, etc.; (*b*) typhoid fever, with its modifications, remittent, typho-malarial, hog-cholera, rouget, etc.; (*c*) diphtheria, with exudative tonsillitis, membranous croup, strangles, and diphtheria in animals, as horses, cats, pigeons, etc.; (*d*) malignant pneumonia; (*e*) tuberculosis, scrofulosis, etc., since on the organic filth in atmospheres of houses must we place primarily the exciting conditions of this scourge; (*f*) septicæmias, as puerperal fever, erysipelas, hospital gangrene, etc.

As a better defined class, we have the *exanthems*, under which we may place (*a*) smallpox; (*b*) rubeola; (*c*) scarlatina; (*d*) Rötheln; (*e*) charbon, malignant pustule or carbuncle, charbon symptomatique, etc. This classification, purely arbitrary, not only indicates how impossible it is to draw hard-and-fast lines on any etiological basis, but also serves to point out the directions in which the work of prophylaxis must be begun and carried out. In the one class, the work is largely one of state medicine and municipal sanitation, including drainage, control of water-supplies, food supplies, etc. The second class, while also demanding municipal supervision, includes the work of household sanitation, and individual hygiene, covering the control of factories, workshops, and hospitals, as regards overcrowding, ventilation, overheating, etc.; while the third class is one which, while demanding household sanitation, makes especially prominent the duty of isolation of cases, and disinfection in its most complete form.

We have treated in a partial way a subject whose ramifications extend into the domain of medicine in all its branches, but what has been said will suffice to illustrate the problems which, not until within the last twenty-five years, have in any way seemed to approach a solution.

Peter H. Bryce.

APPENDIX.

ABSORBENT SYSTEM, DISEASES AND INJURIES OF THE. Anomalies of the Thoracic Duct.—Very many and remarkable instances of deviations in structure, form, course, size, and termination of the thoracic duct are to be found in the literature of the subject. It may begin at a higher or a lower point, consist of one or more branches, divide at one or several points, into two or several subdivisions which may reunite or separately join either the right or the left subclavian vein, or the vena azygos. In one case it terminated in eight branches, two opening into the left, and two into the right, subclavian vein, two into the right jugular, one into the external jugular, and one into the vertebral vein. Instances of double and triple ducts, and of transposition to the opposite side, are quite numerous.

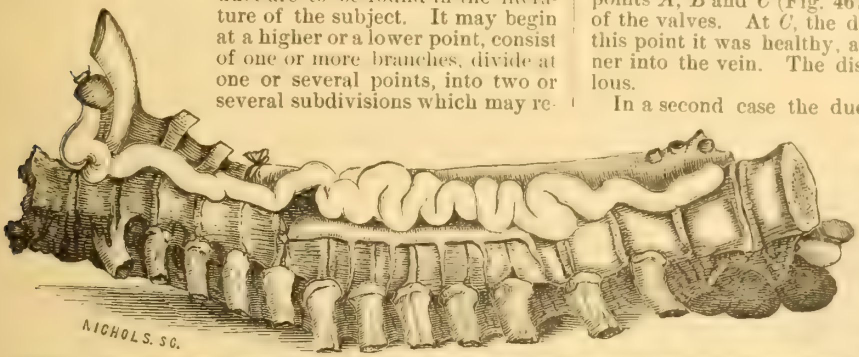

Fig. 4674.—Dilatation of the Thoracic Duct. The aorta, vena azygos, and lower portion of the left internal jugular vein, with that portion of the left subclavian vein which forms a right angle with it, are seen as half distended with course injection, and dried. The thoracic duct is little more than half distended with the injection.

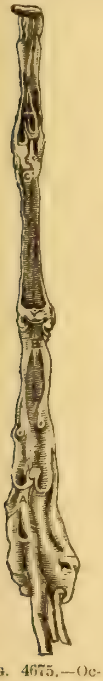

Fig. 4675.—Occlusion of the Thoracic Duct by Thickening and Fixation of the Valves.

Variations in size are equally remarkable. It may be uniformly enlarged from its beginning to its termination, or the dilatation may be irregular. Most usually the enlargement is at its terminus. In several instances, these enlargements have been so considerable as to appear like aneurismal tumors. Matthew Baillie cites an instance in which the duct was nearly as large as the subclavian vein, and Cruikshank asserts that he had seen it "as large as the carotid artery of an adult, or the barrel of an ordinary writing-pen." In most of the reported cases, the dilatation was associated with some morbid condition of the coats of the vessel, but in other instances it was a congenital malformation. The cases of Cruikshank (Fig. 4674) and Amussat (Fig. 4681), are illustrations of this class.

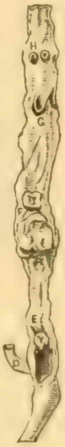

Fig. 4676. Occlusion of the Thoracic Duct by Fungous Growths.

In Cruikshank's case, the man was forty years of age. No obstruction or other cause to which the dilatation could be ascribed was discovered.

Diseases of the Thoracic Duct.—The reported cases of disease of the thoracic duct are not numerous. Cooper observed, in the cadaver of a person who died of phthisis pulmonalis, the thoracic duct occluded at the points *A*, *B* and *C* (Fig. 4675) by thickening and fixation of the valves. At *C*, the duct was obliterated. Beyond this point it was healthy, and emptied in its usual manner into the vein. The disease appeared to be scrofulous.

In a second case the duct was occluded by fungous growths (*E* and *F*, Fig. 4676). In this case the chyle reached the subclavian vein through an anastomosing branch, *D*. The mesenteric glands were enlarged, and the peritoneum was studded with tubercles.

A third case was observed in a laboring man, who had suffered for several months with an enlarged testicle, an abdominal tumor, and enlarged lymph-glands. The testis was a "pulpy mass, composed of broken-down coagulable lymph, and a blood colored serum." The thoracic duct was much altered; its coats were thickened and opaque, and its lumen was obliterated (Fig. 4677). Opposite the curvature of the aorta, the duct was lost in a large tumor, *L*, which differed only in bulk from the abdominal tumor. The receptaculum is seen at *I*; the thoracic duct at *K*; the duct emerging from the tumor at *M*, and the aorta at *N*.

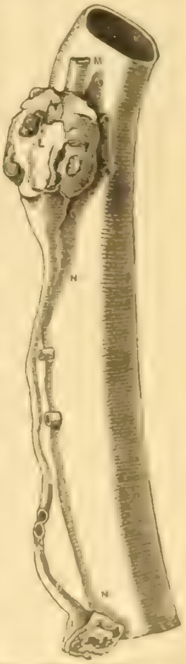

Fig. 4677.—Occlusion of the Thoracic Duct by a Tumor.

In another case the thoracic duct was completely obliterated at *L* (Fig. 4678). The communication between the receptaculum chyli and the subclavian vein was restored by the anastomosing duct *N*, which connected with the duct proper at *O*. This case, like the preceding, illustrates the effort of nature to prolong life by the formation of the anastomosing branch.

The duct has been found diseased in a variety of affections. In a patient dying of phthisis it was found transformed into a fibrous cord; in another dying of chronic nephritis, it was filled with pus, with marked inflammation of its coats; in a fatal case of croup, complicated with pleuro-pneumonia and gastritis, the walls of the duct were thickened, friable, and the lining membrane was inflamed; and in several cases of pelvic abscess the duct has been found diseased, and more or less filled with pus. These pathological conditions, somewhat analogous in character, have been found in association with tuberculous degeneration of the lungs and mesenteric glands, with gangrene of the lungs and abdominal viscera, with suppuration of the cervical glands, with abgans in the kidney and lumbar glands, with uterine sarcoma, pelvic abscess, and cancer of the testicle. It is impossible to adopt any exclusive view in regard to the primary or secondary nature of disease of the duct. It is evident that disease may originate in the tissues of the walls of the duct, but far more frequently it is secondary to some degenerative process taking place in other parts. In all the recorded cases of disease of the duct the lymphatic system has been involved; in some by extension from one part to another by continuity; in others by conveyance of infecting material through communicating vessels, or by contagion from diseased glands in close proximity. Worms has reported a case of idiopathic inflammation of the duct associated with disorganization of the [illegible], which ended in [illegible] by lymphatics filled with pus. The thoracic duct was obliterated at its outlet by a mass pressing upon its descending portion. The remaining portion was dilated to the size of a crow-quill and covered with pus. Its walls were thickened and opaque. The similarity of the morbid products found in the duct to the [illegible] degenerative changes [illegible] in other parts strongly supports the view that in such cases the lesions of the former were secondary, because they were in the line of the onward course of the current toward the venous system.

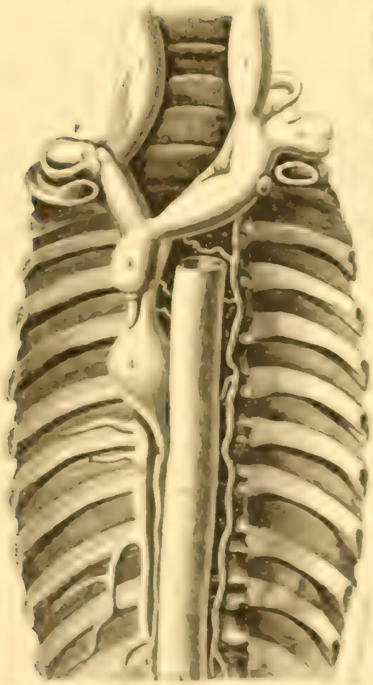

FIG. 4678.—[illegible]

Other kinds of contents of the duct have been observed. Besides blood, pus, bile, [illegible] worms and other extraneous substances, calcareous material has been found in quantities sufficient to completely fill the duct.

Lieutard found, in a scrofulous subject, the mesenteric glands "turgid with a chalky material," and the thoracic duct dilated to more than three times its normal size and filled with the same material.

Cheston reports a case of ossification of the duct (Fig. 4679). It was firm like a "piece of pack-thread," and was entirely plugged up with osseous matter from the receptaculum chyli. In some places the ossification [illegible] was firmly attached to the internal coat. The duct was totally impervious.

Cheston concludes the history of this case with the statement that the appearance of the patient was similar to those who had "[illegible] and been destroyed by slow inflammation of the viscera."

Ould reports the case of a woman who died of acute peritonitis supervening upon a chronic pulmonary affection, in whom the bodies of the last dorsal and five lumbar vertebræ were found destroyed, and the cervical, thoracic, bronchial, abdominal, pelvic, axillary, and inguinal glands were found filled with calcareous concretions. In another case, with an abscess in one of the iliac fossæ, and erosion and destruction of the os ilii, calcareous concretions were found in the bronchial, pelvic, and mesenteric glands.

These calcareous deposits most frequently occur in old persons, and generally consist of phosphate of lime.

In several cases calcareous material was observed in the receptaculum, but always in connection with similar depositions in other parts of the lymphatic apparatus. In a case (Fig. 4680) reported by [illegible], the deposit was found only in the receptaculum.

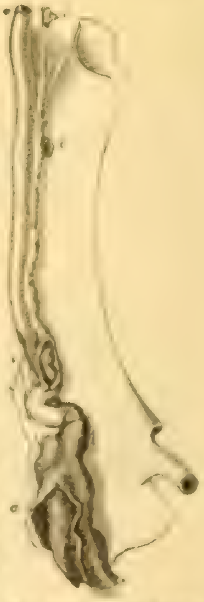

FIG. 4679.—Ossification of the Thoracic Duct. [illegible]

In order that a fuller explanation of the condition might be had, the thorax was opened, and yet the smallest trace of a thoracic duct could be found. It was apparent, however, that a foramen, indicated by the letter A, permitted the escape of the thinner portion of the chyle, by means of which the life of the man was prolonged. No communication of the chyle-conveying vessels with the venous system could be discovered. The coexisting dropsy was undoubtedly due to the interruption in the flow of the chyle.

WOUNDS OF THE THORACIC DUCT.—But few cases of wounds of the thoracic duct have been reported, and most of them are doubtful. In several cases in which an opening or rupture was found in the duct, from which chyle escaped into either the pleural or peritoneal cavity, such opening was the result of disease. There are, however, several cases which must be accepted as authentic. In one of Morton's cases the girl became hydropic "after too great an effort to raise a burden. From the frequent tappings there always issued "a chylous fluid, not unlike milk in color, taste, and consistency." Bartholin refers to a case in which the duct was wounded and the patient lived a long time. Glandorp reports the case of a woman who was wounded in the duct—"at least the mucus and liquid that escaped made it appear so. The patient was nearly cured, but relapsed and died." Hoffman relates the case of a woman who was wounded in the left side by a knife. From the wound a fluid escaped, which was milky during digestion, clear when the patient was fasting, and coagulated spontaneously. Monro reports a case in which lymph escaped through an external wound caused by a stab, and also into the pleural cavity. The case of Gulffart was somewhat similar.

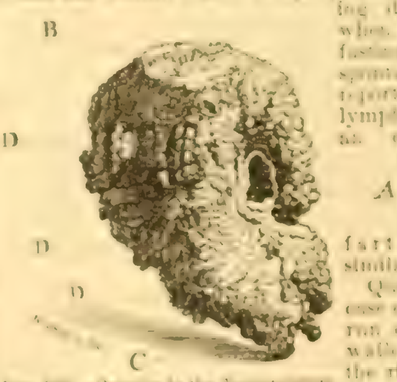

FIG. 4680.—Concretion in the Receptaculum Chyli. A, [illegible]; B, [illegible]; C, [illegible]; D, [illegible]

Quincke reports the case of a man who was run over by a wagon while lying partly upon the right side and abdomen. Dyspnœa set in on the third day after the accident, and increased from day to day until the tenth, when 1,800 cubic cm. of fluid were withdrawn. The fluid was whitish-yellow, resembled milk, and after standing, presented the appearance on its surface as of a white layer of cream about a millimetre in thickness. It exhibited under the microscope minute fat-globules. During the third tapping the patient expired. The right pleural cavity contained 7,000 c.c. of a milky, whitish-yellow fluid. The thoracic duct, from its mouth to the point of emergence from behind the right subclavian vein, was filled with coagulated blood. The lower portion could not be dissected out.

Lower ruptured the thoracic duct of a dog by introducing his finger between the ribs. The animal died after languishing a few days, and two pounds of chylous fluid were found in the right pleural cavity. Monro inflicted a wound in the receptaculum chyli of a pig, which recovered. The effusion of lymph was prevented by a coagulum.

Rupture of the Thoracic Duct, Receptaculum Chyli, and Lacteals.—Clinical and experimental observations have shown that rupture has occurred most often in the receptaculum, and least often in the duct. Post-mortem examinations of cases in which the communication between the venous and lymphatic systems was either partially obstructed or wholly obliterated, are not very numerous. The grouping of such observations is peculiarly instructive. There is no instance of the preservation of the life of the animal beyond a limited number of days, after the communication of the chyle-conveying vessels with the venous system has been completely and permanently obliterated. The free and unobstructed conveyance of the chyle into the blood is essential to the proper nutrition of the body, and to the preservation of life. Death is the result of inanition. This is conclusively shown by gradual wasting and progressive debility, which so markedly characterize such cases. Acute impoverishment of the blood is the inevitable result.

Effusion of Chyle into the Cavities: Chylothorax.—There have been reported ten cases, including the doubtful cases of wounds of the thoracic duct, of lesions produced by either disease or accident, either in the duct or in some of the larger lymph-vessels in the thorax. In five of the cases the chyle escaped from the duct. In one the aperture was discovered only after death; in the others the injury resulted from external violence.

In a number of the cases of chylous ascites, a chylous fluid was also found in one or both of the pleural cavities. In some of these cases, in consequence of obstruction to the escape of the chyle into the subclavian vein, rupture of some small branch of the thoracic duct may have occurred, but it is generally believed that portions of the fluid effused into the peritoneal cavity traversed the lymph-vessels of the diaphragm. The diagnosis of cases of effusion of a chylous fluid in the pleural cavities cannot be made except by withdrawing a portion of the fluid. In Quincke's case of injury by crushing of the chest-wall, the diagnosis was not made until after the evacuation of the cavity. All the cases belong to a class of casualties which do not admit of generalization, and are only instructive in suggesting the occurrence of an improbable contingency, which may happen under circumstances very various and unforeseen. The prominent symptom in such cases is dyspnœa, produced by the accumulation of a fluid in one or both cavities. The nature of the fluid can only be determined by its appearance and examination. In a single instance, a chylous fluid was emitted drop by drop from a puncture through the chest-wall.

Effusion of Chyle into the Peritoneal Cavity: Chylous Ascites.—There have been reported 37 cases of chylous ascites (27 in collection by Busey, and 10 additional cases in collection by Murphy). A number were not originally reported as cases of chylous ascites, but have been classified as such by collators, who have carefully examined the clinical reports.

The causes are various, but may be referred to conditions or some accidental circumstance which produced rupture of the thoracic duct, receptaculum chyli, or lacteal vessels. In a single instance it was due to the puncture of the filaria sanguinis hominis, and in another to "congenital occlusion of the thoracic duct, formation of a compound cystic tumor by distention of the lacteals at the root of the mesentery, rupture of one of the cysts during birth, persistence of this solution of continuity, and increasing effusion of chyle absorbed by the intestines." In most of the cases the chyle escaped through the ruptured wall of the receptaculum, or of one or more lacteal vessels. In several instances the walls of the receptaculum were found diseased, ossified or otherwise changed. In two instances, which recovered, the effusion was manifestly the result of accidental rupture of some chyle-conveying vessel. In much the larger number of cases the effusion was due to over-repletion distention, and consequent rupture of some chyle-conveying vessel, caused by obstruction to the current of the chyle. Such obstruction may result from compression by thoracic or abdominal tumors, enlarged mesenteric glands, peritoneal adhesions, inflammatory thickening of the folds of the mesentery, obstructed pulmonary circulation, interrupted cardiac circulation, stenosis of the thoracic duct at or near its junction with the left subclavian vein, obstructed subclavian vein, impenetrable and degenerated mesenteric glands, and dilatation of the right side of the heart, with stenosis of both auriculo-ventricular orifices. There are a number of cases in which dilatation and rupture of lymph-channels occurred in consequence of impediment to the lymph-stream, but the cases of Virchow, Friedberg, and Cholmely are perhaps the only instances of lymph-varices caused by congenital heart anomaly.

The milky fluid found effused into the serous cavities must be classed, according to its pathological aspects, as either a chyle-like or a fatty fluid. In cases of chylous ascites the effused fluid is chyle, but in other cases of a milk-like fluid found in the pleural or peritoneal cavity the fatty fluid is the product of the coexisting degenerative processes taking place, such as cancer or tuberculosis.

As the effusion of chyle into either the pleural or peritoneal cavity can occur only by transudation or through solution of continuity of some chyle-conveying vessel, its escape externally, or presence in either cavity, must be held as the essential element of differential diagnosis. When the emitted fluid results from transudation the quantity is small, and is usually rapidly absorbed by the peritoneum. When poured out through an aperture in the walls of a vessel the opposite condition exists. If no fluid escapes externally, then only the symptoms indicating the collection of fluid in the cavity will be exhibited, the character of which can be ascertained only by evacuation and examination. The accumulation of fluid can be recognized, and it can be determined whether it is free in the peritoneal cavity or in a cyst. Acute anæmia, with sudden and great prostration, loss of appetite, and rapid diminution of the quantity of urine, associated with a rapid accumulation of fluid in the peritoneal cavity, might suggest the presence of chyle. Dr. Murphy says, in uncomplicated cases due to rupture from violence the symptoms are well marked. "The patient, usually after exertion, is suddenly seized with sharp, localized pain, followed by rapid swelling of the abdomen, suppression of urine, nausea, and vomiting, which in some cases is milky and accompanied by milky diarrhœa." In most cases the loss of chyle by effusion and consequent accumulation is gradual, and the symptoms are more or less obscured by the causative condition. Gradual accumulation of fluid, with great prostration, marked and continuous emaciation, coincident with conditions which would suggest compression of the thoracic duct or interruption of the current of chyle, would suggest the nature of the fluid; but one could not safely assert the fact previous to the withdrawal and examination of a portion. Cystic tumors may usually be readily distinguished.

The prognosis is unfavorable. If the condition be due to the pressure of a removable tumor, recovery is possible by an operation, but in such cases the nature of the tumor usually precludes any hope. The cases of Nickerson and Murphy recovered. In both instances the effusion was the result of rupture of some chyle-conveying vessel caused by a trivial violence. Rest in bed, evacuation of the fluid, and a restricted diet resulted in recovery

I introduce the reports of the two cases following; the first was a case of very long duration with rupture of the umbilicus and discharge of the effused chyle; the other is of a doubtful nature.

Abdominal tumor with milky discharge, reported by Edward Amos, M.D. (Boston *Medical and Surgical Journal*, vol. vii., p. 16, 1832).

"Mrs. Hood, aged about forty, naturally of good constitution, enjoyed comfortable health until the year 1817. While pregnant with a pair of twins, a small umbilical rupture took place from the excessive distention of the abdominal parietes, not larger, as she says, than an English walnut, and which nearly disappeared after delivery. Soon after this period was discovered a tumor in the lower part of the abdomen, which gradually increased in size, became painful, and greatly impaired her general health. It possessed a soft but rather unequal surface, and circumscribed, with occasional paroxysmal pains, and not infrequently attended with some discharge. She, however, became anasarcous, which rendered her extremely large and, in appearance, very near her end. Her breathing became very laborious, and it was with difficulty that she could walk or lie down. But observing that the water exuded from her legs through the skin, I made several punctures with a lancet, which discharged freely for several days, and by the use of a few simple medicines the water unexpectedly subsided, and left her apparently free from dropsy, and so much relieved that she was able to perform the usual labors of her family with but very little help. The abdomen, however, remained much distended by the original tumor. The absence of the water led to the discovery of another swelling in her right side, extending from the spine of the ilium to the diaphragm. This last tumor was discovered about 1825-26, and both together caused her most extreme suffering from the pain of distention; and she several times sent for the neighboring physicians, and entreated them to open her side and give vent to what she believed to be a collection of fluid; but on examination, the tumor appeared solid and without any fluctuation, so that her requests were never complied with. After the above-mentioned period the abdomen began to be more distended, from what appeared to be an ascites, presenting a uniform surface, and the distinctness of the tumors became less apparent. As the disease progressed, the umbilical tumors protruded, and eventually formed a bag of an irregular shape, the apex, which was at the umbilicus, being elevated about five inches from the abdominal surface, and in the middle seven or eight inches in circumference, with two lateral processes resembling nipples about one inch in length. The existence of this singular tumor was unknown to anyone but herself, until an occurrence took place which I am about to mention.

"On the night of the 17th inst. (July, 1832) I was called upon to visit this woman in great haste, as a tumor had burst and was discharging profusely. On my arrival, a distance of four miles and a half, I found her sitting in her chair, with her clothes on, and her finger on the aperture to prevent any further discharge until my advice could be obtained. On inquiry, she told me she went to bed as usual, and about twelve o'clock she was awakened by a discharge from a tumor on her bowels, which had burst. She got up and dressed as quick as her situation would permit, with the assistance of her daughters, and had saved three pints besides what escaped. The friction from the pressure of the finger, for nearly two hours, had enlarged the orifice so much, that sufficient fluid to fill a common-sized pot would escape in a few minutes. About twelve pounds were drawn off while sitting in the chair, and being faint, she was laid on the bed, herself compressing the orifice with her finger; and after a while, three pounds more escaped, when she became too faint to bear any further evacuation, and the remainder was drawn off the next day—being twenty-five pounds in all. This fluid was discharged through an aperture in the umbilicus, which was at the extremity of the tumor. But what involves the whole subject in mystery is, this fluid was milk! and without any disagreeable odor, more than if taken warm from a cow.

"Although the woman is relieved from a great burden, and is able to walk about, she is still encumbered with two original swellings, one on each side, which I apprehend is an enlargement of the ovaries."

Fatal case of vomiting of a chyle-like fluid, reported by Dr. Lawrence Sprague (*New England Journal of Medicine and Surgery*, vol. xii., p. 4, 1823).

"On the afternoon of the 12th of October, I was called to visit a man on board of a schooner lying in the Kennebec River, who was attacked so suddenly, and severely with disease, it was feared he would not survive until I should arrive on board. When on board I was informed that he had done a seaman's duty from St. Bartholomew's to Hallowell, Me., and on the passage had enjoyed good health. One hour before I visited him he had been in the boat with other persons, employed in towing the schooner a short distance up the river, and while engaged in this duty he suddenly requested another person to take his oar, as he could hold it no longer, owing to a severe pain in his stomach and bowels, which so entirely prostrated his strength that he was immediately returned on board. I found him writhing under the most severe pain, which had passed from the abdominal across the lumbar region. Feeling for his pulse, there was not the least arterial action to be discovered at his wrists; and parts of his skin which had been most protected from the weather by the clothes which he wore, were of the same deathly coldness as the rest of the surface. His eyes had a glassy appearance, his countenance pale, and his whole aspect bore marks of immediate dissolution. On the outside of the berth in which he lay, I discovered the food which he had recently eaten and ejected from the stomach, mixed with a great quantity of chyle, it having the appearance of milk in a frothy state. On observing to him that he had puked, and inquiring of him whether he was now sick at the stomach, he replied that he had felt no sickness at his stomach, neither had he been exercised with puking, but that the same kind of fluid (with the exception of more food than had been already thrown up) had continued to flow from his mouth since the commencement of the attack, without the least nausea or act of vomiting. Considering this circumstance very extraordinary, and it having been corroborated by three individuals who had been constantly waiting upon him, my attention was arrested and particularly fixed on a fact, at the time, altogether to be unaccounted for. From the time of my arrival, the fluid resembling milk, which I can have no doubt was chyle, continued to flow so fast from his mouth—with but few seconds intermission, without the least exertion on his part, or the slightest action of vomiting to be perceived—that it was with difficulty he could at times keep from suffocating. It seemed as though it flowed through a channel without any perceptible effort to propel it, and no obstruction to its escape but completely closing the mouth. He was frequently inquired of whether he felt any nausea, and his uniform reply was, that he did not feel the least inclination to vomit; that the matter came up without his being sensible of the power which ejected it. This fluid of a milky appearance continued to flow from his mouth from the commencement of my visit until his death, which took place in half an hour after my arrival. After he was dead, and as long as I remained on board (which was half an hour), as he lay on his back on a board, the discharge from his mouth much increased, bearing the greatest resemblance to the purest milk in a frothy state, unmixed with any other substance. The quantity of fluid thus brought up is variously computed by three individuals who were with him from the commencement of the attack. One of the persons supposed the quantity to have been equal to a gallon measure, others a less quantity. For myself, I could not undertake to decide, but feel confident it was sufficient to produce the coldness which pervaded the whole surface of his body, the loss of pulsation at the wrists, and the fatal consequences which ensued."

The Relation of Obstructed Cardiac Circulation to Lymph Stasis.—Morton performed a number of experiments upon dogs by ligating the thoracic duct; in some the "receptaculum, and in others the lacteals, burst." In every case there was extravasation of chyle. In Sir Astley Cooper's experiments, when rupture occurred it took place at the receptaculum; and Dupuytren's experiments upon horses were followed by nearly similar results. Cooper says it is not necessary to tie the duct. If the animal is fed with milk, and the extremity of the duct is compressed one-half hour afterward, the receptaculum will rupture. Those and similar experiments prove that, under certain conditions involving an interruption or complete arrest of the current of the fluid through the thoracic duct, the resultant distention and dilatation may prove sufficient to produce rupture, which may take place either in the receptaculum or in the lacteals. In those cases in which rupture did not take place, the current of the fluid was re-established through anastomosing branches.

The clinical and post-mortem observations connect directly the process of gradual occlusion of the duct by disease with the concurrent development of a diffuse area of lymphangiectasis, which in some cases terminated in rupture and extravasation.

Monro cites the case reported by Morton of "hydrops ascites lactea," in which the rupture of the lacteals was occasioned by the compression of the thoracic duct near the subclavian vein by large indurated tumors.

Morgagni refers to the cases of Valsalva and Santorino, in both of which there was considerable dilatation of the lacteal vessels produced by the pressure of an aneurismal tumor on the thoracic duct. In Valsalva's case, the aorta, from the heart to the diaphragm, was dilated, and "the lacteal vessels presented the appearance of numerous white spots having a diversity of figure and magnitude."

In the body of a man who died after a large quantity of chylous liquor had been let out of his thorax, Bassius discovered an orifice, at or about the third dorsal vertebra, from which the chylous material flowed as from a fountain. Below this orifice the thoracic duct was pervious.

Cayley reports a case of obstructed thoracic duct and rupture of the receptaculum chyli. "On post-mortem examination some yellow fluid was found in the peritoneal cavity, and the peritoneum in front of the spine was bulged forward by the effusion behind it of a large quantity of milk-looking fluid. The receptaculum was much dilated, and on its anterior surface was a perforation two inches in length. The thoracic duct was immensely dilated throughout its course to its junction with the subclavian vein, where it suddenly became narrowed, and just at its mouth a fibrous vegetation was attached to the lining membrane of the vein which completely occluded the opening of the duct. The narrowed part of the duct was blocked by a firm, yellow, cylindrical coagulum."

Virchow refers to the case he observed in a new-born calf, in which, in consequence of thrombosis of the external jugular vein, the mouth of the thoracic duct was occluded, and nearly all the internal organs were dilated to the utmost with ectatic lymph-vessels filled with a slightly sanguinolent fluid. The intestines especially were covered with broad bead-like canals, arranged so closely together that the intervening tissue could scarcely be recognized.

Ormerod reports a case of chylous ascites in which, on several different occasions, large quantities of a milky fluid were removed. This fluid, Drs. Wilks and Marcet proved to be chyle mixed, more or less, with common serous peritoneal effusion. On post-mortem examination "the left subclavian vein and its afferent vessels were found plugged with a light-colored, ragged clot, evidently of long standing. It was soft in the centre, and at one point was firmly adherent to the walls of the subclavian vein. In the abdomen and chest were also found numerous nodular masses, consisting of an imperfectly fibrous structure."

The preceding citations establish the proposition that retardation or arrest of the current of the fluid in the thoracic duct, at or near its outlet into the subclavian vein, may produce dilatation, distention, and rupture of the lymphatic vessels, and consequent effusion of chyle and lymph into the serous cavities. When the impediment to the flow of chyle and lymph occurs at or near its outlet, the area of stasis and ectasis would necessarily depend upon the duration and extent of such obstacle, and hence, when the area of ectasis is extensive, the manifest inference is that the cause has been one of gradual development and protracted duration. In the case of Bassius, dilatation and rupture were caused by impermeability of the distal extremity of the duct; in Morton's case, the rupture of the lacteals was occasioned by the pressure of a tumor upon the duct near the subclavian vein. In Ormerod's case of chylous ascites, the interruption to the flow of chyle was caused by the "plugging of the left subclavian vein and its affluent branches with a light-colored, ragged clot, evidently of long standing." The resistance to the flow of the contents of the thoracic duct must have been derived exclusively from the interrupted venous blood-current. The heart was normal, and the duct was unobstructed. In Cayley's case of obstructed thoracic duct and rupture of the receptaculum, two factors were in operation, viz., the interrupted blood-current, occasioned by the fibrinous vegetations attached to the intima of the subclavian vein, and the partial obliteration of the lumen of the duct near its terminus. In Virchow's case of the new born calf, the condition existing partially exemplifies the obstructing forces operating in the cases of Ormerod and Cayley. The mouth of the duct was occluded by thrombosis of the external jugular vein. In addition to the slowing of the blood-current in the jugular and in the subclavian, produced by the projecting part of the thrombus, the exit of the fluid from the duct was also impeded.

The influence of partial obliteration or stenosis of the thoracic duct, at or near its termination, in the causation of dilatation or rupture of some part of the lymph vascular system, cannot be doubted. The effects of stenosis produced by the gradual encroachment from disease of the duct, or of surrounding and contiguous tissues and structures, have been shown both clinically and post-mortem. In this latter class of cases, the ectasis is gradual in its development, and more extensive. In those cases in which the lymphangiectasis was consequent upon the slowing or interruption of the venous blood current in the left subclavian vein, the relation of cause and effect seems equally well established. It remains now to show that such diseases of the heart as slow, impede, or stagnate the venous blood-current in the left subclavian or innominate vein, may also produce lymph-stasis. Petters reports a case of lymphangiectasis in which were found, upon the visceral peritoneum, "numerous cysts from the size of peas to that of filberts, some colored bright, and containing serum. Upon the small intestines numerous lenticular protuberances, transparent, and filled with wine-yellow fluid. . . . The glands of the right inguinal region were transformed into cysts of small walnut size, filled with wine-yellow fluid. From the inner wall of these cysts extended dilated lymph-vessels of crow-quill size, which connected the cysts with each other, so that a dilated vas efferens and afferens could be seen in each cyst. Upon puncture, a yellowish fluid spouted from these cysts in a jet of several inches. The lymph-vessels and cysts formed a mass which it was difficult to unravel. The lymph-vessels in the vicinity and the thoracic duct were greatly dilated.

"The heart occupied the entire anterior thoracic cavity. The enormous enlargement of the heart included the entire right side of the organ, so that the left ventricle with the auricle formed only an appendix. The muscular tissue of the left ventricle, which would not contain a hen's egg, was thin and flaccid. The left venous orifice, by the growing together of the apices of the bicuspid valves, was changed into a small crescentic opening, barely admitting the point of the little finger. The latter was callous and enclosing here and there a bony plate. Right ventricle largely dilated, with thinned walls. Columnæ carneæ of both ventricles very slender and insufficiency. [illegible] large as a child's head, [illegible] formed of a thin layer of peri-cardium. Aneurism of ascending aorta pressing [illegible]. Aortic valves incompetent. Right ventricle [illegible] enlarged."

This example [illegible] of the left venous out-flow and a moderate contraction of the right [illegible] opening. Powers concluded that the stasis of lymph, followed by the great dilatation of the lymph-vessels and glands, was caused by the organic disease of the heart. It cannot be doubted that the interruption of the current of blood by the narrowing of the orifices and dilatation of the right side of the heart retarded the movement of the contained fluid in the lymph-vessels. This influence, first demonstrating itself upon the movement of the contents of the thoracic duct, causing distention and dilatation of the vessels of the trunk, produced stasis of lymph in remote vessels. The [illegible] eminences, filled with a transparent fluid, grouped together on the mucous surface of the small intestine, were, probably, ampulliform dilatations of terminal lymph-spaces and the [illegible] on the peritoneum were of like [illegible] and nature.

At the conclusion of this report, Powers refers to the case of an old woman, "suffering with stenosis of the left orifices of the heart," upon whose right arm he found several semi-solid tumors, situated immediately under a [illegible], which he regarded as dilated lymph-glands.

J. Grainger Stewart reports a case of "dilatation of the lacteals," associated with hypertrophied and fatty heart, with diseased aortic valves and dilated auriculo-ventricular orifices. In this case the stasis of chyle occurred in the intestinal villi, producing dilatation of the central lacteal vessels of the villi, and arresting the further absorption of the chyle. To the incompetency of the aortic and auriculo-ventricular valves was added fatty degeneration of the heart. Here enfeebled action of the organ and regurgitation were co-operating factors in arresting the movement of the chyle.

In Rokitansky's case of chylous ascites, there was dilatation of the heart, "with thickening and shortening of the mitral valves." The cardiac affection not only interrupted the flow of chyle in the thoracic duct, but caused a stasis of chyle in the lacteals and mesenteric glands, and of lymph in the lumbar lymphatics, and an effusion of a milk-like fluid into the pleural and peritoneal cavities.

In Hughes's case of abdominal effusion of a chylous fluid, supposed to have resulted from the pressure of mesenteric tumors, "the heart was thin, pale, weak, and flabby," and "numerous lacteals—large, tortuous, varicose, and distended; some with milk and others with a clear fluid—were observed in all parts of the mesentery." The case was complicated with abdominal tumors, "consisting of several agglomerated mesenteric glands," believed to have been cancerous; but from a number of the enlarged glands "a cream-like fluid exuded," and hence it is not improbable that the morbid condition of the glands and lacteals was due to stasis of chyle and lymph, caused by the disease of the heart.

In this connection the case of mitral and tricuspid insufficiency, with granular liver, ascites, anasarca, and thrombosis, reported by Oppolzer, is interesting. The internal and external [illegible] veins were occupied at their [illegible] with pale, yellow, soft coagula. From the superior [illegible] the clot extended with a jagged end into the auricle, and continued into the right subclavian, as well as into the right internal jugular as far as the foramen lacerum. The left innominate and the beginning of the left subclavian were obstructed. The thoracic duct was plugged at its termination by a pale-red, fibrinous coagulum. Its walls were thickened, and its lumen, from the commencement to the [illegible] thoracic [illegible], was greatly dilated. The regurgitation of blood into the thoracic duct was caused by the obstruction to its entrance into the [illegible].

The explanation of this relation of cause and effect between cardiac disturbance and lymph-stasis must, in a general way, be sought in the varying conditions of blood-pressure. A potential, if not the predominant, factor concerned in the flow of the lymph is the difference between the arterial and venous blood-pressure; the greater this difference, the more rapid the movement of the lymph. In a normal condition of the heart, venous orifices, and great afferent and efferent vessels, the blood-pressure in the innominate veins and their affluent branches, during diastole, is at its minimum—represented in comparison with the pressure at the aortic summit as nil; so that, whatever may be the potentiality of the difference between the arterial and the venous blood-pressure as a force in promoting the movement of the chyle and lymph, it is at its maximum when the venous blood-current is flowing most easily and rapidly into the right auricle. Therefore, it must follow that any disease of the heart or any condition of its affluent veins which retards, impedes, or obstructs the free and rapid flow of the venous blood into the right auricle and through the tricuspid orifice will slacken, interrupt, and obstruct the movement of the chyle and lymph in the thoracic duct and its tributary vessels. This conclusion is not derived merely through inductive reasoning, but is illustrated and verified by clinical observation and post-mortem appearances.

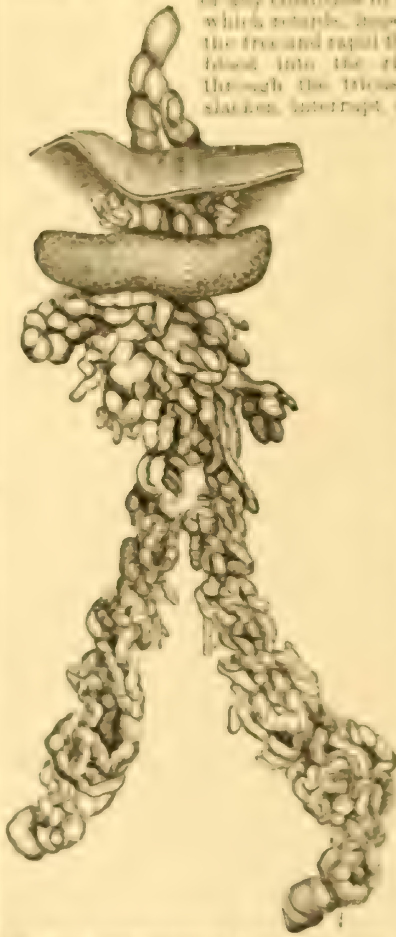

FIG. 4681.—Intra-abdominal Lymphatic Varices.

INTRA-ABDOMINAL LYMPHATIC VARICES.—But few cases of this nature have been reported, and most of them have been mistaken for hernia. The specimen shown in Fig. 4681 was obtained by Amussat, from the body of a youth, nineteen years of age, who during life had carried in each groin a large tumor which was supposed to be a double inguinal hernia, and for which he had worn a truss. Suddenly, after a long journey on foot, he was seized with acute pains under the right breast and in the folds of the groins, difficult respiration, dry cough, cephalalgia, fever, and lancinating pains in the tumors. After some hours of intense suffering he died.

After having turned out the thoracic viscera, the diseased lymphatic vessels were discovered. Some were as large as quills. The mass of dilated and twisted vessels extending to the iliac fossæ were dissected out.

The iliac and crural masses of lymphatics were blown up and macerated, when it was discovered that the hernial tumors were enormously dilated lymph-vessels.

The iliac chain of glands had disappeared, and seemed to have been replaced by lymphatic vessels. No direct communication with the veins was discovered.

The following case, reported by Drinkard, is somewhat analogous. The hernial tumor was discovered in the cadaver of a negro, on the dissecting-table. The tumor occupied nearly all the superior part of the groin, being situated rather more to its outer than its inner border. On dissection a thickened superficial mass was exposed. From the meshes of both of its layers protruded the cellulo-adipose tissue of the region. The tumor was not connected with either the crural or the inguinal ring, and appeared like a mass of cellulo-adipose tissue, interspersed with lymphatic glands undergoing fatty degeneration, and presenting here and there, through its substance, patches of a pale rose color, resembling cellular tissue, infiltrated with blood serum.

Nélaton operated upon a case, in which the diagnosis was uncertain, by making an incision over the mass in the groin, when a quantity of milk-like fluid escaped. The patient was seized with rigors and symptoms of purulent absorption, and died. A similar tumor on the opposite side, which had not been operated upon, was injected, and found to consist of a network of varicose lymphatic vessels.

In the following case, reported by M. Trélat, the tumors were mistaken by Trélat, Nélaton, and the physicians of l'Ile Maurice for hernial tumors. Their true nature was only discovered at the autopsy. The right tumor was situated, in greater part, under the cribriform fascia, in front of the aponeurosis of the psoas and abductor muscles, and consisted of lobes approximating each other; it was definitely bounded above, below, and at the sides, but behind it communicated with the deep lymphatic vessels. From it was discharged, in great abundance, a rose-colored fluid. No hernia could be discovered, but varicose lymphatic vessels occupied the inguinal canal and the superior portion of the cord. Upon removal of the peritoneum from the posterior abdominal wall, there was observed along the iliac vessels a mass of wrapped conduits rolled together, directed generally from below upward. This condition existed on both sides. Toward the columns of the diaphragm these two masses approached, and were probably blended together under the diaphragm. The masses were formed by dilated lymphatic vessels, and resembled exactly the illustration given by Breschet of the condition found in the case of Amussat.

In this connection I reproduce the cases of Petit and Aimé-David, in neither of which was the diagnosis of lymph varices verified. A student had noticed for a year, more particularly after fatigue, a swelling in each groin, which was accompanied with some pain extending down the thighs. Examination showed tumors in both groins, the integument covering which was unchanged in color. The tumors extended into the inguinal canals, and were painful to the touch; the pain extended along the saphena, which region presented the characters of angioleucitis. The boy left the lyceum and returned in eight days, wearing a double truss. The former condition returned, however; the tumors doubled in size, and the limbs became œdematous and benumbed.

The next case was that of a mulatto, about thirty years of age. In consequence of angioleucitis, a very extensive enlargement of the legs developed. At the internal region of the thighs there were present prominent tumors consisting of dilated lymph-vessels. The tumors were uneven, elastic, transparent, and under pressure receded into the abdomen.

Aimé-David refers to another case observed by M. Denis, in which the tumors present were analogous to those found in the patient of Petit. The patient also had a double hydrocele.

The tumor observed by Petters in the right inguinal region of his patient, equalled in size a small apple, and resembled a hernia. It "felt like a conglomeration of ascarides—like rebounding cords, which, upon pressure with the finger, became softer and more flaccid." Petters regarded this anomaly as a "venous plexus," but it consisted of the "glands of the right inguinal region transformed into cysts of small walnut size, filled with wine-yellow fluid. From the inner wall of these cysts trabecular projections extended into the cavity and it was possible to enter two dilated lymph-vessels, of crow-quill size, which connected the cysts with one another so that a dilated vas efferens and afferens could be seen in each cyst. Upon puncture, a yellowish fluid spouted from these cysts in a jet of several inches. Lymph-vessels and cysts together formed a conglomeration which it was difficult to unravel. The lymph-vessels in the vicinity and the thoracic duct showed considerable dilatation." This case was complicated with stenosis of both auriculo-ventricular orifices, enlargement of the heart, œdema, ascites, and cirrhosis, and it does not seem possible to have correctly diagnosed the true nature of the inguinal tumor, which was only recognized after paracentesis.

In view of the history of the foregoing cases, it becomes important to differentiate intra-abdominal varices from hernial tumors. Lymphangiectatic tumors may be confounded with reducible and irreducible tumors. Among the latter may be classed cold abscesses, cysts, and lipomata, which develop slowly, but may be distinguished from lymphangiectatic tumors by their reducibleness, transparency, and indistinct feeling of fluctuation, quite different from that of tumors containing fluid. Lipomata are fixed; they may be compressed, but cannot be reduced. They rarely develop symmetrically, while the inguinal glands on both sides may be affected. Of reducible tumors, lymph varices are most frequently mistaken for herniæ. Both develop slowly; neither changes the appearance or character of the covering integument; both increase in size during exercise and continued maintenance of the erect posture, and both usually recede in the horizontal posture. Hernial tumors do not, however, usually recede unaided, but glandular tumors do. The existence of dilated lymph-vessels in close proximity, the absence of any impulse on straining or coughing, the invariable size of the tumor, and the history of the case, are important data in determining its lymphatic nature. The cases of Trélat and Amussat presented the history and symptoms indicating hernia. In both cases the tumors were reducible and developed slowly. Aspiration and percussion offer the most certain means of differential diagnosis. The presence of a fluid presenting the chemical and microscopical characters of lymph would settle the diagnosis. A lobulated feel, or a sensation as of a congeries of twisted cords unattached and movable, which enlarge when the person is in the erect posture, should excite doubt as to the hernial nature of the tumor. The following case, observed by Fetzer, presented phenomena which should remove all doubt as to the character of the tumor.

"A girl, sixteen years of age, had—besides a double femoral hernia which had existed since her eighth year—upon her abdomen a ribbon-like stripe, commencing one inch below the navel, to the left of the linea alba, continuing to the left and upward, and passing between the false ribs and the ileum, proceeding thence, becoming lighter in color and narrower, as far as the vertebral column. Upon this band, anteriorly upon the abdominal walls, one inch below the navel and two lines from the linea alba, was a conglomeration of several, perhaps eighteen, wart-like tumors, from the size of a male to that of a female nipple, and of the same color as the surrounding skin. They were painless, flaccid, could be pressed into the abdominal walls, but rose upon the removal of the pressure. From two of the protuberances a milk-like fluid exuded continually, drop by drop. The flow issued from a small red spot in the centre of the tumors and was increased by pressure upon any of the unruptured bodies. After standing a short time, the fluid separated into a milky, turbid serum, rendered clear by ether, and a brighter, milky, large coagulum, which reddened upon exposure to the air." Fetzer removed with the scissors one of the protuberances, which was formed by a thin cutis, and immediately from the opening issued in a stream a considerable quantity of the milky fluid, and this was followed by great debility, languor, and a feeble pulse. The entire band was studded with minute raised points. Into the opening artificially made a probe might be passed to the depth of one inch. Chemical analysis of the fluid by Professor Kletzinsky, and microscopic examination by Professor Schlossberger, proved it to be lymph.

CHYLANGIOMA CAVERNOSUM.—In the summary of the causes of varicose lymph-vessels, attention was drawn only to the resulting [illegible] conditions. I will here present an abstract of the case of Quincke, in order to compare it with a case of chylangioma cavernosum, in which chyle retention in the mesenteric lymphatics was occasioned by a very different pathological condition of the mesentery. The following is a report of the autopsy made by Professor Langhans: "Intestinal serosa and peritoneum of parietes thickened and opaque, and covered by numerous fibrinous bands, which connect the intestinal convolutions with each other and with the mesentery and abdominal walls. Here and there these bands were infiltrated with chylous fluid, and consequently milky and opaque. About three metres above the ileocæcal valve, commenced a very dense injection of the chyle vessels, extending to the duodenum, with a perfectly chyle-like milk-white mass. The chyle-vessels were dilated, regularly and irregularly, and alongside of them were larger rounded, slightly prominent, milk-white spots, resembling extravasations. Chyle retention was found upon the villous mucosa of the entire small intestine in a marked degree, and also within the mucosa. In the latter was found an accumulation of chyle spots, and in the lower portion of the ileum the chyle could be seen to assume white flakes. The chyle-vessels were injected exactly to the root of the mesentery with the mesentery, not injected by the latter; mesenteric glands small, without chyle retention. The obstruction to the flow of chyle was caused by inflammatory thickening of both folds of the mesentery, by the transformation of the interposed adipose tissue into dense connective tissue, and by the adhesions along the surface, which glued the [illegible] of the mesentery to each other. The excessive capillary extravasation of chyle into the intestinal walls and peritoneal cavity was occasioned by the closure or compression of the lacteals by the inflammatory thickening of both folds of the mesentery."

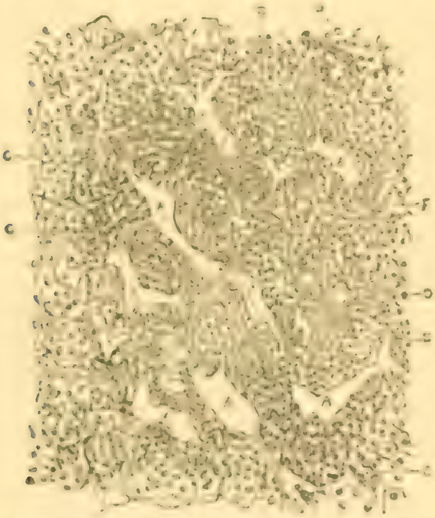

FIG. 992.—Cavernous Chylangioma. A, Fat lobules; B, cavernous [illegible]; [illegible]

Weichselbaum's case of cavernous chylangioma occurred in a man of eighty, who died of senility and pneumonia. Between the folds of the fatty mesentery of the upper ileum there was a tumor of fist-like size and 4 cm. in thickness, which looked like a lipoma. Upon incision into the tumor a watery-white milk-like fluid exuded. Fig. 992 exhibits a section through the tissue.

The tumor consisted of fat tissue filled with numerous caverns of varying size and form, which contained the milky fluid. The caverns formed the larger part of the tumor and [illegible]. The smallest cavern was lined with endothelium. Chemical and microscopical examination of the fluid showed that it possessed all the physical characters of milk.

In this case no extravasation or effusion took place, but the mesentery was transformed into a cavernous structure, the spaces of which were filled with chyle. The cavernous spaces were either dilated chyle-vessels or lacunæ.

In this connection the following case of lymphangioma cavernosum, reported by Hoffmokl, will prove interesting, because of its locality and the result of the treatment:

Adolf A——, aged two months; moderately nourished; anæmic; expression of face suffering. In the dorsal decubitus of the patient the entire right half of the thorax and lumbar region was seen to be occupied by a tumor, which extended upward to the crista ilii, forward to about one inch from the right edge of the sternum, and backward to the right transverse processes of the vertebræ. Length of tumor, 19 cm.; width, 16 cm.; height above normal level, 7 cm. The skin covering it was traversed by partly smaller, partly larger dilated veins and showed at the superior portion of the tumor several bluish, elastic places averaging three or four lines in diameter. Upon the external side of the tumor was seen a dark-red teleangiectasis, confined to the skin, and 1½ inch long by 1 inch in width. At the upper portion of the tumor the skin was retracted in an umbilicus-like manner in a place about one inch long, yet presenting no trace of a scar. The surface of the tumor appeared lobular, especially in the anterior upper and lower portions; the tumor itself was very elastic and fluctuating at the most prominent portions. It could be somewhat diminished by pressure. During the crying of the child it became tenser and more tense. Percussion of the tumor gave an empty (dull?) sound everywhere. No other alteration in the thoracic and abdominal organs. The tumor at its upper portion appeared somewhat transparent. Exploratory puncture gave exit to about two ounces of clear, yellowish, lymphoid fluid, when the tumor collapsed somewhat, and then showed still more distinctly that it consisted of numerous caverns, which perhaps communicated with one another by several canals. The fluid itself was feebly alkaline, coagulated after about a quarter of an hour, and after a time the fibrinous cake expelled the serum, similarly to what occurs in a bloodclot. The specific gravity of the serum was 1.020. Microscopically, a small number of lymph-cells could be demonstrated; 100 grammes of the fluid contained: serum albumin, 2.585 Gr.; fibrin, 0.085 Gr.; globulin in small quantity; and salts of the blood serum. No lymph-vessel epithelium could be discovered.

Six days after the puncture the tumor was nearly as full as before. Dr. Hoffmokl again punctured at another place, and obtained the same fluid, but scarcely two drachms. Three days afterward erysipelas was developed in the seat of the entire tumor. The tumor became tense and painful, and the child seemed to be much debilitated. Cooling applications with the addition of lead water were made, and by the end of a week the erysipelas had almost wholly disappeared, and the tumor was much smaller, and presented at many places a distinct hardness, caused probably by coagulation of its contents. The appearance of the child was improved.

Twenty-six days after the second puncture the erysipelas had disappeared entirely, the tumor was flat, smaller by two-thirds, solid in the lower, but fluctuating in the upper, portions. The appearance of the child had by that time very much improved.

SIMPLE LYMPHANGIOMA.—Simple lymphangioma, which is exclusively a congenital form, may be illustrated by the following cases of macroglossia and macrocheilia.

"A child, two years of age, had, from birth, a thick tongue, which had greatly increased during the preceding two weeks. The tongue protruded from the mouth in a broad, thick, hard mass, and was closely encircled by the stretched lips.

"Upon the posterior under-surface lay, in partly bead-like rows, bluish transparent vesicles, varying from very fine, just visible bodies, to the size of large flaxseeds.

"Upon longitudinal section through one lateral half of the ablated portion, the cavernous tissue was found principally in the middle part corresponding to the region of the transverse muscle, as shown in Fig. 4683.

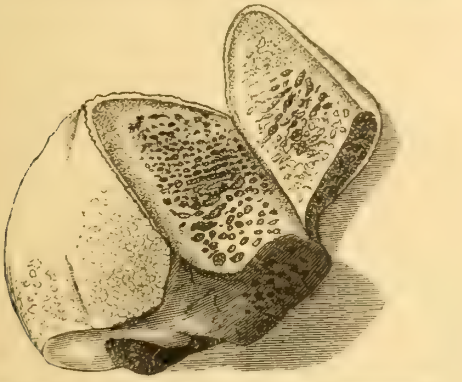

FIG. 4683.—Lymphangioma of the Tongue (Macroglossia).

"Upon the top could be distinguished the whitish, tough layer of the mucous membrane and the papillæ; below it a longitudinally striated, very tough, and whitish layer; next, the cavernous mass, and below, again, a more longitudinally striated layer, which continued beyond the apex. The same result was found upon transverse section, and the cavernous structure appeared in the centre in very coarse meshes, while toward the lateral portions it became fine, and toward the periphery the mesh cavities became smaller and smaller, in such a manner that bead-like vesicles could be traced up to the papillæ. The cavities were elongated perpendicularly, and varied in size from the smallest, barely visible points, to over a line in their greatest diameter. The width of the trabeculæ varied. Many of the cavities communicated by narrow openings; many, however, appeared closed, and the adjacent vesicles could be seen shining through at the bottom; the trabeculæ and partition walls which bounded them were sharply defined, more or less smooth, and pale."

"C. R., fifteen years of age, was born with a thick upper lip. He often suffered with swelling of the glands of the neck during childhood, without suppuration ever taking place, and several times the upper lip had been inflamed and much swollen, which had subsided, leaving only an increased enlargement of the lip.

"The excised portion collapsed very much, and showed to the naked eye a distinct cavernous trabecular tissue, and a lymphoid serous fluid could be pressed from the deeper caverns, while coagula were formed in the smaller caverns. The trabeculæ were formed in part of connective tissue only, in part also by fibres of the orbicularis oris; the largest cavities were of the size of small peas, the smallest microscopic."

"E. S., aged seven months, suffered from congenital macroglossia, which, about every four weeks, was attacked with some inflammation attended with difficult deglutition, dyspnœa, and considerable enlargement of the neighboring lymphatic glands. The volume of the tongue was increased after each attack, finally attaining the size of an ordinary apple, felt very tense to the touch, was dark red; its surface was covered with a thick, white coating. The strongly developed papillæ gave to the surface a thickly villous, furry appearance.

"The protruding portion was amputated, and on examination its parenchyma was found to have degenerated into a cavernous meshwork, whose trabeculæ were partly formed of white, firm, connective-tissue cords, partly by muscle-bundles. The fluid within the meshes of the cavernous tissue coagulated into very white coagula, which looked like fibrin coagula, and consisted of lymph-corpuscles."

Virchow insists that the "bead-like, bluish, transparent vesicles, which varied in size from just visible bodies to the size of hempseed," found on the under surface of the ablated portion of the tongue, were dilated terminal lymph-spaces, and communicated by very fine apertures with deeper-seated vessels, or with the cavities of the cavernous tissue of the parenchyma. For, although this connection could not be demonstrated, it could be shown that the cystoid spaces, probably dilated lymph-canaliculi, became smaller and smaller toward the surface, and, finally, bead-like vesicles could be traced up to the papillæ. The characteristics of the cavities with which the hypertrophied portions of the tongue were interspersed, can only be explained upon the supposition of the primary ectases of lymph-channels. In Billroth's case of macrochilia, cavernous trabecular tissue, from which a lymphoid fluid could be pressed, was distinctly visible to the naked eye; and in the other case, he found a cavernous transformation of the parenchyma containing a lymphoid fluid. Neither Billroth nor Virchow succeeded in establishing a direct continuity between the caverns and lymph-capillaries, but the microscopic character of the fluid was sufficient. In one of Billroth's cases of macrochilia, it was not possible to distinguish the fluid from lymph, and in the other it consisted of lymph-corpuscles and fibrin. Virchow maintains that the cystoid formations found in the nodes of congenital hypertrophies, are formed by the dilatation of the lymph-spaces, though their communication with lymph-vessels may not be recognized. Billroth, though holding that congenital macroglossia and macrochilia may be either solid or cystic, concedes that the cysts owe their origin to occlusion and dilatation of the lymph channels; and O. Weber asserts that congenital lymph-angiectases of the tongue and lip find their cause in dilatation of the terminations, or, more correctly, of the calibre of the lymph-vessels.

CHYLOUS HYDROCELE; GALACTOCELE; CHYLOCELE; LYMPHOCELE.—Cases of effusion of a milky fluid into the tunica vaginalis have been reported by Vidal (de Cassis), Ruthman, Ferguson, and others. The cases of C. H. Mastin, and W. M. Mastin occurred in the city of Mobile.

The fluid in the case of Vidal was composed of water, a substance analogous to albumen, and fatty matter. It was alkaline and coagulated spontaneously. Under the microscope there were seen a multitude of small globules having the appearance of the globules of butter. In the case of Ruthman the contents were the color of milk with a greenish-yellow tinge, and they thickened and coagulated spontaneously. In Ferguson's case the fluid was indistinguishable from milk, and emitted a peculiar odor.

The cases of Mastin and son, of Mobile, Ala., have been more carefully observed and studied, and seem to have determined the nature and cause of the effusion, as well as a proper method of treatment. The first, by C. H. Mastin, occurred in a man twenty-two years of age; five feet and eleven inches in height; weight, one hundred and fifty-seven pounds; of robust health, and bilious temperament; brunette. Eight years previously he had noticed an enlargement of the scrotum, which gradually increased for four years, when he was tapped, and a quantity of "white fluid" was drawn off. The same operation was repeated three times, and when seen by the reporter, the sac exhibited every appearance of a hydrocele. It was tapped a fourth time, and eight ounces of a thick, milky fluid evacuated. The sac was dense, firm, and elastic. Testicle slightly enlarged, but no evidence of disease of the gland. The fluid was alkaline; specific gravity, 1.015; highly albuminous; and composed of innumerable molecules, and some small granular cells resembling colorless blood corpuscles, floating in a ser one pint. The fluid in its chemical and physical qualities was comparable to chyle. The patient had refused again until one year had elapsed. The tumor was then opened by an incision three inches in length, and eight ounces of the same kind of fluid were discharged. The sac was found [illegible]. The cavity was smooth, polished, and pearly white, and, at the junction of the cord with the testicle, a small, round, glandular-looking mass, about the size of an English pea, was seen. This was snipped off, and at its base were observed the patulous orifices of three or four small vessels, which did not bleed. These vessels were dissected back, and being found to pass into the cellular tissue around the cord, were tied en masse with a silk ligature, the ends of which were brought outside. The front wall of the vaginal tunic was excised, its edges [illegible] with a drainage-tube by silk sutures, and the cutaneous wound was closed by the pin suture. Recovery was rapid. Five years afterward the patient was seen and carefully examined. There had been no return of the disease.

To Dr. C. H. Mastin is due the honor of first having observed a lymphatic varix on the surface of the tunica vaginalis, though Lebert,[1] as early as 1855, had suggested the possibility of its occurrence in cases of chylous hydrocele.

The second case occurring in Mobile is reported as follows by Dr. W. M. Mastin: H. E. A., aged twenty-two, white, American, a decided blonde, somewhat below medium stature, a carpenter, and a resident of Mobile. Four years previously he had noticed that both testicles were enlarged, firmer than natural, and the seat of considerable and dull pains. At the time of examination the right tumor was the size of a man's fist, pyriform in shape, opaque, somewhat elastic, with slight fluctuation, and at its posterior and upper parts, in the region of the cord, filled with irregular, tortuous, worm-like masses, resembling a varicocele. The left tumor was much smaller, with no perceptible fluctuation, not transparent, but marked by similar convoluted and tortuous masses, which were somewhat diminished by the recumbent position. By aspiration three ounces of a milky fluid were withdrawn from the right sac, which exhibited the usual chemical and microscopical characteristics of similar fluids. Upon opening the sac there was found on its upper and front surface a smooth and rounded lump. This nodule was pedicled and oozing, and after its removal a milky fluid oozed from the patulous mouth of the vessel, nearly as large as a knitting-needle, in the stump. Previous to its removal it had been transfixed at its base with a needle armed with a double catgut ligature, each ligature being tied separately and cut short. Recovery was complete.

The appearance of the varices in these two cases differed only in that in one there were visible the orifices of three or four ducts after the varix was snipped off, and in the other the mouth of a single vessel only. In both cases the varix was located on the anterior surface of the sac, at the junction of the cord with the testis.

The third is reported in abstract as follows by Dr. W. M. Mastin, and is the first in which the filariæ have been discovered.

J. F. M., a [illegible] by occupation, twenty-two years of age, born in Mobile, of Irish parentage, [illegible], of slender frame but moderately robust, came under observation on September 27, 1887, suffering from an enlargement of the left testis. Inquiry elicited these points in his history: There is no evidence or history of either hereditary or acquired disease. His father died of acute cerebral congestion at the age of fifty-three, but his mother is still living in the enjoyment of good health, as are the other members of his family, consisting of five brothers and two sisters. His own health has always been excellent, and, with the exception of the usual diseases incident to childhood, and a short attack of malarial fever in the fall of 1885, he has never suffered from fever, or, indeed, from serious or wasting illness of any kind. His bowels are [illegible]. His appetite and digestion are good, but he complains of nervousness and disturbed sleep, the result, probably, of irregular hours consequent upon his occupation of night-watchman. His habits are good and he is not a drinker, although he indulges in an occasional glass of beer. His residence is located in a [illegible] portion of the city. He has never been out of Mobile and its immediate vicinity. The water ordinarily consumed for drinking purposes by himself and family is supplied by the "City Water Works," but is occasionally derived from a drove well, the former being pumped up from a clear running stream into an open reservoir, from which distributed to the town. He does not remember to have drunk cistern or tank water, or any standing uncovered water. Eight years ago his right testicle passed up into the inguinal canal, where it has since lodged; this he attributed to immoderate exercise, although he has no recollection of any injury connected therewith.

The left testicle began to enlarge three years ago, but was without pain, and, indeed, the only discomfort experienced therefrom is the inconvenience resulting from its bulk.

Examination shows him to be fairly nourished and apparently in good general health. The right testicle is atrophic, insensitive, and occupying a fixed position about the centre of the inguinal canal. The left testis has the dimensions of a medium-sized pear, is pyriform in contour, fluctuating, semi-transparent (by transmitted light), and painless—in a word, presenting the characteristic features of an ordinary hydrocele.

The glands in both inguinal spaces are moderately enlarged and in chains—each gland being easily outlined and traced to its association with another. There are also a few enlarged glands in the right axilla and the right cervical region, but no other lymphatic enlargement is discernible, and, in fact, there is no evidence of any other disease whatever. The left tunica vaginalis was tapped, and four and a half ounces of milky fluid withdrawn. The testicle was neither enlarged nor painful. This fluid was alkaline in reaction, albuminous, of a yellowish-milky color; and, as shown microscopically, contained numerous fat granules, some leucocytes, casts, epithelial scales, and embryonal filariæ in active motion.

The sac slowly refilled and was retapped twice. The first time was on November 7, 1887, when about one-half ounce was removed; three slides were examined, with the result of finding fourteen of the embryo nematodes. The final tapping was on May 19, 1888, and resulted in the removal of one ounce of fluid and a "find" of five embryos in three slides. These were all active and vigorous, and remained alive until the desiccation of the liquid medium.

Repeated blood examinations were made, but always with negative results, although great care was observed in conducting them, due regard being had for diurnal migration and inversion of this periodicity.

VARICES OF THE LYMPH-VESSELS OF THE PENIS.—The varying forms of varices of the lymph-vessels of the penis are shown in the following cases. Dubois reports the case of a man aged thirty years, who a year previously had contracted a urethritis, the acute period of which was complicated with lymphangitis of the prepuce and [illegible]; resolution took place, but there remained on the anterior surface of the penis little knots, [illegible] near the raphé. On the left side a reddish, nipple-like pimple was to be seen, terminating at its summit by a grayish point, alternately opened and closed. From this there passed a subcutaneous knotted cord parallel to the median raphé of the penis; the skin was not adherent, and had not changed its color. At its posterior extremity the cord terminated in a nodosity, adherent to the skin, and on which existed two grayish openings resembling the one before described. Pressure being made upon the knotted cord, a sero-purulent fluid escaped from the openings; a stylet introduced into one opening penetrated the cord and passed out through an opening of the other extremity. Between the openings described there existed another in the middle of the cord, at which the cord adhered to the subcutaneous cellular tissue, which was the point of anastomosis of the affected with the healthy lymphatics."

In this case the valves, though incompetent, were present, hence the characteristic knotted condition. When entirely absent, such portion of the vessel will expand uniformly.

Huguier reports the case of "a man, aged thirty-nine years, who had a right inguinal hernia, and for two years had used a bandage. On the penis, at the base of the glans, was seen a congeries of transparent vessels, hard, tortuous, and three or four millimetres in diameter. These vessels seemed to arise from the frænum of the prepuce, from whence each could be seen dividing into three or four branches, a little smaller, but quite as hard and tortuous, crossing toward the root of the penis and dipping into the fibrous tissue of the envelope. Through a puncture a dull, almost colorless fluid escaped, followed by collapse of the vessels."

Huguier's case was characterized by great dilatation, transparency, and thinning of the vascular walls, due to the incompetency of the valves, as shown by the complete evacuation of the fluid and collapse of the vessels.

The following case of Friedreich exhibits the rosary and cylindrical forms of dilatation in combination:

"A youth, aged eighteen, had a simple, non-indurated chancre upon the external end of the penis. When nearly healed, the lymphatic glands in both groins began to swell and to pain, followed by turgescence and a painful swelling of the whole penis. Simultaneously was observed a vessel surrounding the corona glandis like a ring, having its beginning on both sides of the frænum, running thence upward in the furrow behind the corona, and continued above in a thicker second vessel, which extended along the median line to the root of the penis, but receded gradually inward, escaping more and more from view, and finally could only be discovered by the touch. These vessels were very prominent above the surface; felt full, elastic, painless, and were recognized as dilated lymph-vessels by their whey-like, dull-white contents, as well as by their rosary-like arrangement. From the circular vessels radiated numerous thinner vessels of the calibre of knitting-needles, which carried the same contents, but being dilated equally, did not present the same rosary-like arrangement, and which, receding after a short course upon the glans into the deeper tissues, soon escaped from view. The periglandular abscesses in the groins were incised and a quantity of pus was discharged. With the gradual disappearance of the inguinal tumors and healing of the wound the dilated lymph-vessels were reduced to their normal size."

The varying form of ectasis, which was cylindrical in the smaller, and irregular and rosary-like in the larger, proves conclusively the incompetency of the valves in the former, and their competency in the latter. The gradual disappearance of the lymphangiectasis with the cure of the periglandular abscesses, and removal of the compression of the inguinal glands, established the relation of the stasis of lymph in the vessels of the penis to the impermeable groin-glands.

Causes.—The most frequent cause is coition. Balanitis, chancre, urethritis, periadenitis, impermeable inguinal glands, and congenital defects which interrupt the current of the lymph, are also occasional causes.

Diagnosis.—To obtain a good view of the lymphatic varicosity the folds of the prepuce must be obliterated by drawing down and making tense the skin of the penis, when it appears in the form of a little rounded cord, resistant and hard to the finger, in which has accumulated a limpid, aqueous liquid, which cannot be expelled through either of the extremities. The varicose vessel being confounded with the folds of the prepuce, and directed from behind forward, and from above downward, there is a dorsal extremity situated near the median line, and a frænal extremity bordering upon the frænum of the prepuce. The cord presents intersections which mark the localities of the valves. If with a needle a slight puncture be made in the dilated cord toward the frænal extremity, that portion is emptied which is situated between the puncture and the intersection; but if made in the dorsal extremity, the whole cord will be emptied. The course of the lymph is toward the dorsal extremity, in which direction the valves open. When the varices are confined to the superficial vessels, the diagnosis may be made by the hard, knotted, flexible cords along its course. When ampullar, they are usually small rounded tumors, reducible by pressure, but resuming their form upon removal of the pressure. Sometimes the fluid discharged through a fistula or puncture is dull and colorless, in other cases it is milky. In some cases collapse of the vessels follows puncture. When the varix is caused by coitus, it is at first intermittent, but after frequent recurrence becomes permanent.

Treatment.—Beau varies the treatment according as the affection may be intermittent or permanent. In the first form he employs local applications of cold water and astringent solutions. But when continuous, he operates by passing a needle armed with a thread through the frænal extremity, and along the vessel for a short distance, then out through the wall of the vessel. He then ties the two ends of the thread traversing the dilated vessel, and conceals them in the cul-de-sac of the prepuce. As soon as inflammatory action is set up, as evidenced by slight pain and swelling, the thread is removed. The swelling disappears in a few days, and in the course of a few months the hard and knotted vessel has entirely disappeared. It is not necessary to traverse the entire vessel with the thread, but it is important to introduce it at the frænal end. When the varix is caused by enlarged, compressed, or impermeable glands, the cause of the interruption to lymph-flow must be removed by an operation.

Samuel C. Busey.

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[1] Narrowing, Occlusion, and Dilatation of Lymph-channels, Acquired Forms, by Busey. p. 86.

ANTIFEBRIN, or ACETANILIDE. The popular name of this new antipyretic is as much open to criticism as are those of drugs in general which are called from the clinical effects that they are expected to produce rather than with reference to their chemical constitution. We shall soon exhaust the possible combinations of Greek and Latin words in describing the particular symptoms produced by drugs of this class if chemistry continues to be prolific. We have already antipyrin, antifebrin, and antithermin; and a recent writer informs us that we still can dispose of such names as contrapyrin, contrafebrin, contrathermin, and contracalorin, after which we shall be forced into new directions to keep pace with the activity of chemistry.

Antifebrin was first made by Gerhardt, and is chemically an anilin in which one atom of hydrogen has been replaced by the acid radical acetyl. It is made on a large scale by boiling (with arrangement for condensation and reboiling of vapor) one hundred parts of chemically pure anilin with one hundred parts of anhydrous acetic acid. This process of boiling is kept up until the product, when treated with a weak solution of caustic soda, no longer allows the precipitation of any free anilin. At this stage the process of fractional distillation is resorted to. At 120° C. the acetic acid passes over, at 295° C. the acetanilide distils from the retort. This solidifies on cooling, forming a crystalline mass, which is subsequently purified by recrystallization with animal charcoal from distilled water.

It occurs in the shape of colorless, odorless, silky, rhombic crystals, having a fatty feel. When placed upon the tongue it causes a slight burning, and it is of mildly bitter and not unpleasant taste.

It is soluble in 189 parts of cold water, and is freely soluble in hot water, in alcohol, and alcoholic fluids like wine; also in chloroform and in ether. Its chemical formula is $C_6H_5NH(C_2H_3O)$.

It melts at 112°–113° C., forming a clear fluid, which boils at 292°–295° C. It is of neutral reaction.

The therapeutic properties of antifebrin were first discovered by Cahn and Hepp, and their results have been very frequently confirmed in all parts of the world.

Its uses are numerous. Locally it has been found to be a bland and unirritating antiseptic in the treatment of wounds.

Given internally to a healthy man, it is not likely to cause a fall of the temperature, but if it be given to a febrile patient it causes a decided diminution in the fever, accompanied frequently by a lessening of the frequency of the pulse and an increase in its force. The power of this drug to cause effects of this kind seems to be at least two or three times as great as that of antipyrin. The maximum effect is produced in the third or fourth hour after the dose has been taken, and it is continued between three and ten hours, depending upon the size of the dose. Defervescence is often accompanied by a general reddening of the surface of the body, with more or less profuse perspiration, and is followed by a subsequent elevation of temperature which is sometimes accompanied by a pronounced chill. Occasionally, especially if large doses are given, there may be alarming symptoms of depression, approaching even to a condition of collapse.

During the apyretic period there is often diuresis and quiet, refreshing sleep. The drug is well borne by the stomach and there is, indeed, no danger attending its use other than the condition of depression just referred to, which is often accompanied by cyanosis.

The blood shows the spectrum of methæmoglobin. Occasionally, but not often, it has caused an eruption of an itching character, which manifests itself especially in the development of dark-red spots upon the face and forehead. Mydriasis, deafness, and ringing in the ears have been noted among its effects.

The fall of temperature does not seem to be dependent upon the sweating, for the latter phenomenon can be prevented by the administration of atropine without preventing the antipyretic effect.

Experimentally it has been found, if given in enormous doses, to cause death, preceded by loss of reflexes, tremors, convulsive movements, great fall of temperature, frequent, irregular, and superficial respiration, retention of urine, coma, and general paralysis.

Prolonged action of the drug has produced fatty degeneration of the heart, liver, and kidneys.

Its influence over fever has been shown to be especially marked in typhoid, intermittent, and hectic fevers, that effect being distinctly less pronounced in pneumonia, puerperal fever, and measles.

It has been found of value in the treatment of acute rheumatism, as a specific, its effect being often quite similar to that of salicylic acid. It has also proved of value in the treatment of neuralgia of various kinds, including facial neuralgia, migraine, and the lancinating pains of tabes.

ADMINISTRATION.—It can be used pure upon wounds as a powder, or to impregnate gauze. For internal administration the dose is from five to ten or fifteen grains. Larger doses have often been given, but they are not unlikely to produce unpleasant symptoms of collapse as already noted. It can be given in wafers, or in alcoholic solutions, if the patient is taking stimulants of that class, or it can be given in pill form. Collapse is much more likely to be caused by it if the fall of temperature induced by it coincides with a normal remission in the course of the disease. Opinion is divided as to whether it produces more lasting results if given in a single full dose, or in very frequently repeated small ones.

George L. Peabody.

ARTIFICIAL FEEDING OF INFANTS. When the natural means, wholesome maternal milk, the only perfect nourishment of infants, is wanting, it becomes a serious problem how best to substitute a suitable food. The importance of the problem will be appreciated when we consider the dire results which generally follow attempts made in ignorance, or with imperfect knowledge, to hand-feed infants. The enormous death-rate which, in all countries, occurs among those deprived in early days of maternal milk is sufficiently startling, while among those that survive, the too frequent defective health, stunted growth, and even actual deformity, plainly attest the failure.

The problem also gains greatly in importance from the frequency with which it confronts us, and it would appear, from recent writers, that the number of American-born mothers who, for one reason or other, are unable to nurse their infants is on the increase. I am, however, unable to give any statistics relative to the subject.

Important recent advances have, however, been made in our knowledge both of the causes of failure and of our means of combating them, and a satisfactory solution of the difficulties can, in the majority of cases, under good home management, be now assured. But it involves unremitting care. Minute instructions must be intelligently and efficiently carried out by the mother or trustworthy nurse, under frequent medical supervision, and all in charge must feel that no point is too insignificant to receive the closest attention. A recent writer goes so far as to say: "There can be no doubt, though the statement is a bold one, and seemingly contrary to nature, that, among the average, infants properly brought up by hand are better developed and enjoy more perfect health than those completely breast-fed." My own experience does not accord with this, except in the cases where lactation has been unduly prolonged, or where the mother's health is defective. Bottle-fed infants are not as strong on the average as those fed with wholesome maternal milk, even when all their surrounding circumstances are most favorable. On the contrary, I believe they feel the influence of unhygienic conditions much more quickly, and more severely, than do those fed at a good breast. Doubtless, in many of the infants for whom bottle-feeding is necessary, congenital debility, as Dr. Parker, of the East London Hospital, has pointed out, may have much to do with the results. "It does not need any long experience," he says, "to enable one to pronounce that if the mothers are weakly, the offspring likewise will be weakly, and in estimating the causes and treatment of marasmus and other kindred diseases in infancy, it seems to me that too little stress is laid on the congenital debilities under which numbers of children labor." Certainly the task of rearing an infant by hand, even with all the knowledge and skill we can command, will be found one of very varying difficulty. If the powers of digestion are naturally strong, and especially if the infant has received the advantage of maternal nursing for some weeks, until its gastric and intestinal secretions have become somewhat developed, our task of supplying a suitable food may be a comparatively light one, requiring only care. But if the infant inherit a weak constitution, with feeble powers of digestion and assimilation, still worse, if it must be bottle-fed from its birth, great difficulties will be experienced, and in large cities, especially during the summer season, the prospects of such cannot be said to be favorable. In all cases we must recognize the necessity of such infants enjoying the powerful tonic and stimulating effects of pure, fresh air, plenty of sunlight, and careful general hygiene. When these, for any reason, cannot be supplied, our chances of success are much diminished.

We must remember, also, that an infant is not nourished by what it swallows, but only by that portion of its food which is digested and assimilated. A proper dietary, therefore, must be adapted to the infant's age, constitution, and digestive powers, so that, as far as possible, everything swallowed may be digested and absorbed. "And as children differ as much in constitution as in features, it is impossible exactly to formulate a food that will be applicable in every case." As age and strength increase, there is a corresponding development of the gastro-intestinal functions, and a call for more and stronger food. On the other hand, should the system be reduced by disease, the digestive, sympathizing in the general debility, loses somewhat of its power, and assumes that of an earlier age. In such cases the impaired strength must be sustained and increased by giving only such food as may be completely assimilated, and not by forcing down strong food merely because it is strong, for the latter, when not vomited, passes through the bowels undigested, and the little creature starves to death in the midst of plenty, or dies from the ill effects of the constant presence of fermenting food in the alimentary canal. On these accounts many changes in diet, as to quality and quantity, must be anticipated and made." That this may be done intelligently, it is desirable at the outset to have clear ideas on the principal physiological facts connected with infantile digestion.

PHYSIOLOGY OF INFANTILE DIGESTION.—We notice, first, that the *secretion of saliva* during the first few weeks of infant life is very small in amount, and its diastatic effect is slight and slow in action. This is due to the imperfect development of the glands of the mouth. The parotid is the most developed. Keating detected distinct but very feeble amylolytic action in the secretion as early as the seventh day, but the quantity secreted is very small compared with what it afterward becomes. The submaxillary and sublingual are still more backward in development. About the end of the second month the amount of saliva increases considerably, and its diastatic power becomes greater. In infants of large size and good development the secretion is stronger and more abundant than in delicate infants of the same age; while in infants weakened by disease the secretion is apt to remain defective. According to Korowin, the diastatic effect of the saliva of a baby of eleven months was found to be as strong as that of an adult. During these early weeks any uncleanliness of the mouth renders the secretion acid and interferes with its action.

Different varieties of starch are found to vary in the rapidity of their transformation into sugar under the action of the ferment. The starch of barley, oats, and potatoes are among those that are more rapidly changed. It is said that the effect of the saliva on the food persists for some time after its introduction into the stomach, but ceases as soon as the secretion of hydrochloric acid takes place. This, Uffelmann found, was not till after the first half-hour of digestion. Before this, lactic acid only is present. In the older infant this may be important, for although no mastication takes place, probably a considerable amount of saliva, which may have a very distinct action in the stomach, may be swallowed shortly after, or along with, the food.

As far as we know at present, there are no essential differences in either the digestive processes or the secretions of the infant's stomach as compared with those of the adult. At this early age the shape of the *stomach* is somewhat cylindrical, its position is almost vertical, and its muscular structures are little developed. Its capacity is variable and difficult to estimate. Frowlowsky's investigations indicate a rapid growth for the first few weeks, and a more gradual one afterward. The rate of growth, as evidenced by the capacity, may be represented in ratio, according to him, by the following figures: 1 for the first week, $2\frac{1}{2}$ for the fourth week, $3\frac{1}{5}$ for the eighth week, $3\frac{1}{8}$ for the twelfth week, $3\frac{4}{7}$ for the sixteenth week, $3\frac{3}{5}$ for the twentieth week.

The *secretion of pepsin and acid* would appear to be fairly active within the first few days after birth. In digestion the absorption of the watery and saline constituents of the milk begins at once in the stomach. The casein is coagulated by the pepsin, to be dissolved again after a little while. The presence of acid appears to aid the coagulation, but is not absolutely necessary. The secretion of the pepsin is stimulated by the absorption from the stomach of such liquid elements as are capable of being thus treated. The secretion of acid is augmented when the contents become more solid. Hence hard curds increase acidity, while the addition of water affects the amount of pepsin. In the artificial digestion of casein, when the action of the pepsin has ceased, it has been observed that it may be re-established by the addition of water simply; but in the stomach, not only does the supplying of water have a similar effect to what it has in the retort of the chemist, but in addition it stimulates the secretion of more pepsin, and assists the exit from the stomach of what has already been digested. As a rule, water is not supplied sufficiently to infants. Even in breast-feeding, it has been noticed that any cause rendering the milk more concentrated than normal interferes with its digestibility. In artificially fed infants there is a strong tendency, during gastric digestion, to the development of acid in excess. This is owing partly to the liability of the sugar to undergo acid fermentation, and partly to the fact that cow's milk is apt to form hard, firm clots, which favor excess of acid secretion. This excessive acidity may have a disastrous effect on intestinal digestion, and may alter nutrition generally throughout the body. The *secretion of bile* takes place, as we know, even during utero-gestation, and after birth it appears to be found in considerable quantities. During the early months its function is probably principally eliminative. The *secretion of the pancreas*—the gland associated with the salivary in the conversion of starch into sugar—is during early life in a still more undeveloped condition than that of the salivary glands. It remains very feeble in action till after the sixth month. Under the influence of the bile and pancreatic juice, the fats of the food are emulsified and become fit for absorption. It appears, however, from the investigations of Wegscheider that, even under the most normal circumstances, when no food but mother's milk is given, a considerable amount of fat is eliminated with the fæces, partly as a soap, partly as a free fatty acid, and a portion in an unchanged condition. From this Dr. Jacobi infers that care should be taken not to give too much fat, lest we thereby derange both digestion and assimilation through the formation of fat acids in large quantities.

In reference to *intestinal digestion* in the infant our knowledge is still very imperfect. Absorption is rapid through the numerous and large villi whose capillaries are said to be larger than similar capillaries in the adult. The special glands are few in number and only slightly developed. Of the amount of the *intestinal secretion proper* we have no exact knowledge. The large intestine does not aid in digestion. It will absorb water and soluble substances, but whatever is absorbed in this way, such as albumen or sugar, unless it be predigested, is soon eliminated by the kidney. The formation of acids in the intestinal tract is very liable to take place, especially in artificially fed infants. Reference was made above to the same tendency in the stomach. We have, in addition, in the intestinal tract, the presence of a large amount of mucous secretion, along with the possible presence of undigested material, both of which easily undergo acid fermentation. The alkaline secretions of the liver, pancreas, and intestines are easily neutralized, and new acids are formed from material which ought to have been digested by them, giving rise to irritation, and, possibly, diarrhœa. But, besides this, an excess of free acid in the infantile intestines is injurious by breaking up the combinations of phosphoric acid with lime and the alkalies so needed by the growing tissues, and thus allowing their elimination from the system. Hence the tendency of such infants to suffer from rachitis, and the necessity of maintaining an alkaline state of the upper bowel to avoid its development.

A *suitable food for an infant* must contain all the elements required for its nutrition. Nitrogenous material it must have to supply waste and the wants of its growing tissues. Without it starvation of the tissues will surely ensue, but the amount required is small compared with the proportion existing in adult food. Carbohydrates must also be present. On them we depend for the production of heat in a being whose muscular activity is comparatively slight, yet in whom the activity of the vital processes would be greatly impaired were its body-heat lowered in any degree. More than that, they are found to be essential to nutrition and to the chemical changes that take place during the activity of the several tissues. Fat especially appears to be intimately associated with new cellular growth. The carbohydrates, however, must be in an assimilable form, and we notice that little or no provision is made by nature for the digestion of starch during the early months of life. Possibly the secretion of the intestinal glands may have some amylolytic action, but it is probably only slight. It is asserted that several forms of bacterial life, which are found in the intestinal tract of infants, have a distinct effect in this way, but the exact influence of these micro important enzyme at present very problematical. Carbohydrates must be supplied, therefore, in the form of some sugar, and of these milk-sugar appears to be the most acceptable. The fats must be in the state of a fine emulsion. There can be little question that the administration of starch in any quantity, during the early months of infancy, is opposed to the conditions of normal infantile physiology; and practically we find that a food containing much farinaceous food, when supplied to young infants, results sooner or later in defective nutrition, and gives rise to acute diarrhœa and marasmus. It is requisite for the food to contain mineral matter also. Phosphate of lime is required for the hardening bones, and chloride of sodium and iron for the blood daily increasing in amount. Sodium salts also undoubtedly do much service in the vital processes of digestion, absorption, and nutrition, processes for which a full and sufficient supply of water is also required.

HUMAN MILK COMPARED WITH OTHER MILKS.—Having thus briefly considered the distinctive features of infantile digestion, we require the supply of a suitable food; and this, according to the consensus of all, must correspond as closely as possible, in chemical composition and general properties, with healthy breast milk. With this end in view, many careful analyses of mother's milk have been lately made to find out its exact composition, and to discover wherein it differs from the milk of the several domestic animals to which we naturally turn for an efficient substitute.

One of the most thorough analyses recently made is that of Professor Leeds, of Hoboken, who in a very able paper on the subject of Infant Foods, read before the College of Physicians of Philadelphia, gives the following results:

Analyses of Forty-three Samples of Woman's Milk, Reaction Uniformly Alkaline.

	Average.	Minimum.	Maximum.
Specific gravity	1.0313	1.0[illegible]	1.0[illegible]
Water	86.73	[illegible]	[illegible]
Total solids	13.266	10.92	16.93
Fat	4.13	2.11	6.89
Milk sugar	6.987	5.40	7.92
Albuminoids	1.996	1.06	4.86
Ash	[illegible]	0.138	[illegible]

He adds: "Not only was the reaction alkaline when the samples were fresh, but, with one exception, in which it was neutral, the alkalinity was found to remain for at least twenty-four hours afterward."

Baginsky quotes the following as the result of very numerous analyses by Pfeiffer:

Result of analysis.	1st day.	6th day.	8th day.
100 parts contain:			
Water	86.82	86.92	87.72
Total albuminoids	2.[illegible]	1.[illegible]	1.[illegible]
Casein	1.[illegible]	1.[illegible]	1.[illegible]
Albumen	[illegible]	[illegible]	[illegible]
Non-nitrogenous substances	[illegible]	[illegible]	[illegible]
Fat	[illegible]	[illegible]	[illegible]
Sugar	[illegible]	[illegible]	[illegible]
Salts	[illegible]	[illegible]	[illegible]

Both of these are particularly interesting as, in part, explaining the wide divergence in the results obtained by chemists in their analyses. All analyses, however, agree in asserting that human milk contains all the elements necessary to constitute a perfect food—proteids; carbohydrates in the two forms of fat and sugar; salts, and water. On examining these tables, however, we find that we have by no means a constant combination of these materials. All of them appear to be more or less variable. The most striking peculiarity in woman's milk, says Professor Leeds, is not the constancy, but the great variability in its composition. According to his analyses the proteids are the most changeable constituents, with a maximum of 4.86 per cent., and a minimum of 0.85. Then come the fats and salts, whose maximum is about three times the minimum. The sugar shows comparatively little variation. Pfeiffer finds that the period of lactation has also much influence, and that during the first days of nursing, human milk contains more proteids and salts than it does later on. These both decrease rapidly, while the percentage of sugar at the same time rises.

We have here, then, to do with a fluid which, while containing all the elements necessary for the perfect nutrition of the infant, contains them in quantities which are liable to considerable variation according to the period of lactation, to the age and temperament of the mother, and perhaps to some special condition, which we are unable to appreciate, in the mammary glands themselves. Being drawn direct from the gland into the infant's mouth, it may be said to be absolutely free from germs. In the great majority of cases infants digest and assimilate it easily. It would appear, therefore, that in our substitutes we can may allow some slight variation, provided that we retain the great qualification of being easily digested and assimilated, to which, undoubtedly, the aseptic state of the food is a necessary condition. In seeking a substitute for mother's milk, the attention is naturally directed toward the similar products of the mammary glands in other mammalia, and of these the milk of the cow, goat, ewe, ass, and mare, are more or less available for our use. Careful analyses have been made of these, with the following results:—

	Cow.	Goat.	Ass.	Mare.	Ewe.
Water	87.7	85.50	90.5	90.[illegible]	82.0
Albuminoids	3.42	4.50	1.[illegible]	1.[illegible]	7.9
Fat	3.[illegible]	4.[illegible]	1.3	1.[illegible]	5.8
Sugar	4.[illegible]	4.[illegible]	6.2	6.[illegible]	4.9
Salts	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.7

Of these the nearest analogues are the milks of the ass and mare, but they can never become generally available, although an attempt is now being made at the Hôpital des Enfants Assistés to use that of the ass in the case of those infants suffering from hereditary contagious disease.

Goat's milk is more frequently available, but possesses no advantages over cow's milk. It appears to be rich in fats and its peculiar odor is often objectionable to the infant. Kraus says that the coagula which form from goat's milk under the action of rennet and acid are less dense than those of cow's milk, and more like the coagula of human milk; but this assertion has been denied, and on making the experiment one's self, there appears to be little difference between the curd-forming elements in the milk of the two animals. Routh, however, states that these qualities of the milk may be much controlled by the food given to the goat, and that, when it is fed on beet-root, as opposed to straw and trefoil, the amount of the casein and fat are both lessened by more than one-third. He also says that the peculiar smell is not essential, and may be greatly diminished if the animals are kept clean, washed from time to time, and not allowed to associate with the rams. In certain cases this milk may have the very important advantage of being obtainable fresh. Where good cow's milk is not available it may be carefully tried, care at the same time being given to the feeding of the animals. In the preparation of it for infant feeding it will be noticed that it generally contains a larger proportion of fats, albuminoids, and salts than does cow's milk, while the percentage of milk sugar is less.

Cow's milk has many advantages. It is plentiful everywhere, and is easily and cheaply obtained. Next to ass's milk, it most nearly corresponds in chemical composition with human milk, and it should have no objectionable properties in the way of taste and smell. The formula of its chemical composition is thus given by König, and for the sake of ease of comparison we place the result of his analysis of it side by side with his analysis of woman's milk:

	Mean.		Maximum.		Minimum.	
	Woman's.	Cow's.	Woman's.	Cow's.	Woman's.	Cow's.
Water	87.09	87.41	90.90	91.50	83.69	80.32
Total solids	12.91	12.59	16.31	19.68	9.10	8.50
Total albuminoids	1.94	3.76	4.25	12.44	0.57	1.58
Casein	0.63	3.01	1.90	7.40	0.18	1.17
Albumen	1.31	0.75	2.35	5.04	0.39	0.21
Fat	3.90	3.66	7.60	7.09	1.71	1.15
Milk-sugar	6.04	4.92	7.80	5.67	4.11	3.20
Ash	0.49	0.70	?	0.87	0.14	0.50

On comparing these tables we notice much similarity between the two fluids. Both exhibit considerable variation in the albuminoids and fats, and constancy in the amount of milk-sugar, while the amount of difference between the two averages is in no case so great as the variation between the maximum and minimum of each. Yet on closer examination we shall find important differences which demand careful study and correction, if we would successfully utilize the cow's milk in the preparation of food for infants. These differences may be stated as follows :

1. While human milk is always alkaline, and remains so for many hours, the reaction of cow's milk is in general acid ; especially when the cow is stall-fed. When pasture-fed it is more or less alkaline at first, but quickly becomes slightly acid. This acidity is in part due to the preponderance of potassium biphosphate in the milk, and probably in part also to the presence of more or less lactic acid.

2. While albuminoids are present in human milk in only half the quantity that they are in cow's milk, the two are found to differ essentially in their curd-forming properties. Cow's milk, according to Leeds, on the addition of a coagulating acid yields up nearly four-fifths of its albuminoids as a rapidly forming and firm coagulum, very slowly dissolved by gastric juice ; while, on a similar treatment of human milk, only one-fourth of the albuminoids are coagulated in the form of a flaky and easily digested curd, while the remaining three-fourths do not undergo alteration.

At first this difference was but imperfectly appreciated. Lehmann thought it was principally due to the more alkaline reaction of the human milk, and says : "I have found woman's milk, when acid, yield a much thicker coagulum than when alkaline, and cow's milk, when alkaline, a much looser coagulum than when acid ; facts which are of the greatest interest and value in relation to dietetics." Biedert insisted on a much more radical difference in the caseins ; and more recently numerous chemists have made investigations of the properties of the two. Radenhausen says that the proteids in woman's milk exist as albumen, protalbumen, and peptones, and that there is little or no real casein in it. Struve finds in woman's milk about one-sixth the quantity of insoluble casein, twice the quantity of soluble casein, three times the amount of albumen, and one-third more peptones than he finds in cow's milk. Simon found that after complete desiccation the proteids in woman's milk are freely soluble in water, while those of cow's milk are largely insoluble. Bouchardat and Quevenne, Meggenhoffen and others, state that the casein of woman's milk forms soluble compounds with small amounts of acids, while the casein of cow's milk is coagulated by the same. Thus, although there is still disagreement as to the exact nature of the albuminoids in each, all admit the much greater digestibility of those contained in woman's milk as compared with those of cow's. Dr. Brush has explained this property of forming hard curds as belonging to the milk of all cud-chewers, in contradistinction to the softer and more flaky curds of the milk of those animals which are not cud-chewers. He says : "The young of the former all chew the cud soon after birth, therefore the milk designed for their use contains a variety of casein which coagulates into a mass sufficiently hard and consistent to be regurgitated and chewed." This statement appears probable, though I am not aware of its having been corroborated. There can be little doubt that this difficulty in the digestibility of the proteids forms our chief obstacle in utilizing cow's milk. The excess of the proteids, even supposing they were equally digestible, is, however, not unimportant. In the case of two children, one nursed from the breast, and the other fed upon undiluted cow's milk, each taking the same quantity of milk per day, the second will obtain nearly double the amount of proteids obtained by the first ; but as the latter generally drinks more than the former, the excess becomes even greater. Escherich has found that an infant thus fed took, on an average, a litre of undiluted cow's milk per day, containing 34.64 grams of proteid, while a child of the same weight, nursing from the breast, took only 774 grams of milk, containing 12.93 grams of proteid, per day. Even if all this excess were digested it cannot be assimilated, and can therefore do no good, but only harm.

3. The amount of the carbohydrates, even in pure cow's milk, falls below that in woman's milk in most of the analyses published ; while if we compare the ratio of the proteids to the carbohydrates in the two milks, the slight deficiency becomes a considerable one. In woman's milk the proportion of albuminoids to milk-sugar is as 1 to 3.11, while in cow's milk the relation between these food-stuffs is as 1 to 1.31. Hence if the milk be reduced to avoid excess of proteids, a very marked deficiency both in fats and in carbohydrates will occur.

4. An analysis of the saline ingredients in the two milks shows a considerable difference in the relative amounts of the sodium and potassium salts.

The following is the result of Bunge's analysis as given by Hoppe-Seyler. One thousand parts contain :

	Woman's milk.	Cow's milk.
Potassium oxide	0.7799	1.766
Sodium oxide	0.2315	1.110
Calcium oxide	0.3281	1.599
Magnesium oxide	0.0636	0.210
Ferric oxide	0.0039	0.0035
Phosphoric acid	0.4726	1.974
Chlorine	0.4377	1.697
Total amount ash	2.2186	7.977

The proportion of the potassium salts is thus greater in woman's milk than in cow's milk : the lime salts are in excess in cow's milk, but the latter contains a slight deficiency in the amount of iron. The differences, however, appear too slight to require much correction.

THE PREPARATION OF COW'S MILK FOR INFANTS' USE.—With the above facts before us, our study must be directed to the means at our disposal to correct, if possible, these differences between the two milks, and the first point which demands our consideration is the prevention of the dense indigestible curds which are a constant source of irritation. *Simple dilution* will to some extent hinder this, both by diluting the acid of the gastric juice and by lessening the amount of casein. It favors also, to some slight extent, the secretion of the pepsin by promoting the absorption of the soluble substances in the milk. Hence, in all our methods it should be more or less employed, but the effect is too slight to be depended upon without other means. Lehmann was one of the first to point out the effect of *the addition of an alkali* in rendering the curd less dense. The alkali also acts by partially neutralizing the acids met with in the stomach, so that coagulation takes place more slowly. Lime-water, and sodium or potassium bicarbonate, are frequently employed for this purpose. When lime-water is used, it is, I think, advantageous to add it in somewhat larger quantities than is frequently directed. As it contains only half a grain to the fluid ounce, it may be added to the extent of one-fourth or even one half of the amount of milk employed. An efficient substitute for lime-water is the liquor calcis saccharatus of the British Pharmacopœia, which is made as follows: Take of slaked lime, one ounce ; refined sugar in powder, two ounces ; distilled water, one pint. Mix the lime and sugar by trituration in a mortar ; transfer the mixture to a bottle containing the water, and, having closed this with a cork, shake it occasionally for a few hours. Finally, prepare the clear solution, with a syphon and keep it in a stoppered bottle. From five to fifteen drops of this solution may be added to each half pint of milk mixture. Should constipation be present in the infant, the carbonate or bicarbonate of potassium may be used in the amount of four or five grains to the pint of milk. [illegible] recommends [illegible] as an occasional diluent. In this method, it should be remembered, the use of alkalies in too large quantities may weaken the digestive juices and render the infant flatulent. It is, moreover, only partially effective, and in young infants and those of weak digestion is insufficient to prevent much gastric difficulty, although it may be more often employed in addition to other methods. Another plan, more efficient than the previous, is the one frequently referred to as mechanical, in which, instead of plain water as a diluent, a solution of some substance is used which, by its physical consistency, is apt to diminish the density of the coagulum. This method is an old one, as we read that Van Swieten, in the fifteenth century, used decoctions of wheat or barley for this purpose; but its utility has of late years been very strongly urged by Dr. Jacobi. Its practical advantage has also been proved by Professor Leeds, who, in a series of careful experiments, showed that the coagulum precipitated under such circumstances was a far more friable material which, by incorporating therewith, acts as an attenuant. The coagulation will also in such cases take place much more slowly—a very positive advantage, as it affords the digestive fluids and the peristalsis of the stomach a better opportunity for action. Many substances have been used for this purpose. Dr. Jacobi appears to favor a decoction of gum arabic as the diluent in the case of very young infants. It is, he says, absolutely indifferent from a chemical and physiological point of view, as it is not acted on by the digestive fluids and is not absorbed, but acts mechanically only. I have myself more frequently used a solution of gelatine in such cases. A good method of preparation for this is as follows: Put a piece of plate gelatine an inch square into half a tumblerful of cold water, and let it stand for three hours; then turn the whole into a teacup; place this in a saucepan half full of water and boil until the gelatine is dissolved. When cold this forms a jelly, of which two teaspoonfuls or more may be added to each half pint of food. For older children well-boiled decoctions of barley or oatmeal form a highly recommended diluent. Dr. Jacobi writes: "I have always preferred barley when an article for steady diet was to be recommended, for the reason that oatmeal, on account of its containing fat and mucin, tends to relax the intestines sooner than barley meal. Otherwise the chemical composition of both is so nearly alike that it would make but little difference upon which the choice would fall. . . . . In the case of very small children it will pay well to allow the barley-corns to boil for hours, in order to let the outer layers burst and yield their contents, as in this way the largest part of the starchy matters in the centre will be got rid of by straining. Otherwise it is better that the people should grind the barley themselves in a coffee-mill reserved for that purpose, and thus shorten somewhat the time required for boiling." When the ordinary pearl barley is used, he says that much of the gluten is lost in the husk. Dr. Eustace Smith recommends the following as a convenient mode of using the barley: "'Two tablespoonfuls of washed pearl barley, with a pint and a half of water, are put into a saucepan and boiled slowly down to one pint. It is then strained and the liquid allowed to set into a jelly. A few teaspoonfuls are used in the preparation of each half pint of food.' It is better, however, when practicable, to prepare it freshly every time. In this case one or two teaspoonfuls only of the barley are used in the above recipe, and the resulting decoction is added directly to the milk." Dr. S. C. Busey urges the advantage of arrowroot, substituting this, prepared in a similar way, to the barley, and says that he has often witnessed its beneficial effects in cases of diarrhœa and vomiting. I have myself found it to agree when the others had failed.

The disadvantage of all these diluents, however, for very young infants is that they introduce a material quite foreign to milk, and with which their digestive powers are unfit to grapple until their salivary and pancreatic secretions become more fully developed. It must, therefore, be clearly understood that the introduction of the starchy elements in this method is not intended for nutritive purposes, but simply as an attenuant of the casein, and used in this way Dr. Jacobi thinks that a small quantity may be introduced into the intestine without giving rise to disturbance. It is very necessary, however, that the percentage of starchy matter should be small, and that it should be very thoroughly boiled. Dr. Smith recommends several hours, so that a portion may be changed into its soluble form. If thus carefully used, I have no doubt that in infants of fair digestion this method is very frequently of practical advantage, notwithstanding theoretical arguments against it. Dr. J. Lewis Smith has recently urged the claims of *dextrine*, a partially digested starch, as a distinct advance on these previous methods. He writes to the Secretary of the Sub-committee on Infant Feeding of the American Medical Association as follows: "According to my observations babes can digest dextrine readily—even those under the age of three months, who digest starch with difficulty." His plan of preparing it is the following: Take from five to ten pounds of well-selected wheat flour (that made by the Hungarian process is the best); put this dry into a bag and tie firmly. Boil it for several days, preferably five or six, then take it out and scrape off the rind of dough carefully. The hard, dry inside must then be grated and sifted, and placed for two days in pans in an oven at a temperature of about 180° F. The starch, by this process, is largely converted into dextrine, but not into glucose. It is thus only partially digested, and, in his opinion, conduces to a better and more healthy condition of the infant than when fully digested. When kept for use it is also more stable than the glucose preparations made from Liebig's formula, and it acts better as a mechanical diluent. I have myself frequently used this formula with great satisfaction.

In addition to this mechanical method of preventing the coagulation of the casein, we can have recourse, especially in infants of weak digestive power, to the *partial digestion* of it, thus rendering it more or less the physiological equivalent of the albuminoids in human milk. There are several ways in which this may be accomplished. One of the first proposed was that of Professor Frankland, in which the casein of a portion of the milk is first peptonized by fresh calf's rennet. The directions for this are as follows: Allow one-third of a pint of new milk to stand for about twelve hours; remove the cream and add this cream to two-thirds of a pint of new milk as fresh as possible. Into the skim-milk put a piece of rennet about an inch square (this can be obtained from the butcher). Set the vessel in warm water till the milk is fully curdled, which will be in from five to fifteen minutes, the rennet being removed as soon as curdling commences, and put into an egg-cup for future use, as it can be employed daily for a month or two. Break up the curd thoroughly and separate the whole of the whey; then heat it rapidly to boiling, when a little more casein will separate and must be removed by straining. One hundred and ten grains of milk-sugar is now to be dissolved in the hot whey, and the whole mixed with the milk and cream mixture previously made. This gives us one pint of artificial human milk, which should be used within twelve hours after its preparation. All vessels and apparatus concerned in the manufacture must be kept scrupulously clean. Instead of this fresh rennet some liquid preparation of pepsine and acid would doubtless answer the purpose equally well, and would appear to be free from the objection associated with using rennet kept for some time. This method has the strong recommendation of the Sub-committee on Infant Feeding.

In this country Professor Leeds has strongly recommended the use of pancreatin, and a firm in New York has made a preparation of it suitable for the purpose of predigesting milk. The directions for its use are thus given: "Put into a clean quart-bottle five grains of extractum pancreatis, fifteen grains of bicarbonate of soda, and four fluid ounces of cool, filtered water; shake thoroughly together, and add a pint of fresh cool milk. Place the bottle in water so hot that the whole hand may be held in it for a minute without discomfort (120°–130° F.), and keep the bottle there for exactly thirty minutes. At the end of that time put it on ice to check further digestion and keep the milk from spoiling." The fluid obtained, while somewhat less white in color than milk, does not differ from it in taste. If, however, an acid be added, the casein, instead of coagulating in large, dense curds, forms small, soft flakes, resembling the curd of human milk. At this stage the casein is only converted into peptone; but, if the heat be continued, the liquid becomes grayish-yellow in color, has a distinctly bitter taste, and shows no coagulation whatever on the addition of an acid. The peptonization is now complete, but it is undesirable, for many reasons which we shall refer to presently, that this stage should be reached. To seize the proper moment for arresting the process, the person in charge must taste the milk frequently, and, as soon as the least bitterness is appreciable, the bottle must be removed from the hot water and placed on ice, so as to be immediately cooled. In my own practice I find it generally desirable to stop before the bitterness is detected, and to judge the effect by the time rather than by the taste, otherwise the later portions of the digested food are apt to become very bitter. To facilitate this process, a "peptogenic milk powder" has been prepared containing pancreatin and bicarbonate of soda, along with some milk-sugar. When the food is wanted, milk, water, and cream are added to some of the powder, and the whole heated over a brisk flame to a temperature of about 130° F., and kept at this heat for six minutes. When properly prepared the resultant, so-called humanized milk, presents the albuminoids in a minutely coagulable and digestible form, has an alkaline reaction, a not unpleasant taste, and contains about the same amount of proteids, carbohydrates, and fats as exist in human milk. When the necessity for predigestion passes away, an ordinary milk diet can be gradually resumed by regularly diminishing the time that the artificial digestion is allowed to progress. These processes are reported by many as having given excellent results in their hands. In my own they have not proved as successful as I at first anticipated. In their employment some skill and intelligence are requisite, and these qualifications are not always at our command. Scrupulous care must always be exercised in the selection of the pancreatin, as it is very liable to become decomposed, and the use of the stale, foul-smelling preparations sometimes met with in the market, for the peptonizing of infants' food, can only be condemned as liable to introduce impurity.

It is very doubtful also, to my own mind, whether the addition of the large amount of alkali apparently necessary for this process is not decidedly injurious. After the peptonizing process has proceeded sufficiently, I prefer to have the milk boiled, so as to insure, as far as possible, sterilization, and to check further action of the ferment. The cases in which complete digestion of the proteids is requisite are very few. On this point Professor Vaughan gives a necessary warning. He says the employment of completely digested foods may be admissible for a short time in case of extreme weakness, but their continued use is not to be recommended. In the first place, the digestive organs may be weakened if the food used for any length of time be completely digested before its administration. Like other parts of the body these organs need exercise, and, if relieved of their physiological duties, are liable to atrophy and become less efficient in action. Moreover, the use of wholly digested proteids in quantity is not free from danger. Albertoni and Schmidt Mühlheim have shown that if peptones be injected directly into the blood they are poisonous. Normally it is a function of the liver to arrest and alter the products of proteid digestion in the stomach and intestines; but if a great quantity of ready-made peptones be poured into the stomach they may be absorbed so rapidly that the liver will fail to perform this function fully. Again, Breiger has shown that the artificial digestion of proteids is accompanied by a poisonous base, to which he has given the name peptoxine. Whether this substance is found in normal digestion or not, we do not know; but if so, it must be altered or eliminated by the liver. Certainly it cannot be altogether safe to pour a large quantity of this poisonous base into the stomach of a child. Hence, while the partial artificial digestion of the casein may be not only admissible but desirable, its complete digestion demands much caution in its employment. Before leaving the subject of the coagulation of the casein it may be stated that, by simply boiling milk we remove a small amount of casein, and the coagulation of the remainder is rendered somewhat less dense.

Besides having to get rid of the hard casein curds, we have in our conversion of cow's milk into an infant food to deal also with the excess of proteids, which by most analyses amounts to about double the quantity found in woman's milk. This can be corrected by simple dilution with water, in which case the quantity of the fats and the carbohydrates will require to be increased by the addition of cream and cane- or milk-sugar. It may also be very effectually accomplished by removing the casein altogether from a portion of the milk, as in Frankland's process, and then adding the whey with the cream to the remainder. The amount of the proteid that should be allowed to remain has been a subject of discussion. Dr Biedert recommended, as the result of his experience, that in children of weak digestion the amount of the proteids should be reduced to not more than one per cent., and more recently Dr. A. V. Meigs, of Philadelphia, has insisted that in our preparation of cow's milk the albuminoids should not exceed this amount. He further says that the direction generally given, to increase the strength of the dilution as the child gets older, is of doubtful propriety, for human milk twelve months after delivery is but little altered from what it was at the end of the first or second month. His directions for preparing a food are as follows: Seventeen and three-quarter drachms of milk-sugar are to be dissolved in a pint of hot water and the solution kept in a cool place, care being taken that at no time is it to be used if there be the slightest trace of souring in it. When the child is to be fed the nurse should mix together two tablespoonfuls of cream, one of milk, two of lime-water, and three of the sugar solution. When the mixture has been warmed sufficiently it is ready to be fed to the infant.

If the infant be healthy, this amount will not satisfy it after the first few weeks, and then these quantities will require to be doubled. The food should not, however, be given any stronger until the child is eight or nine months of age at least; but, if it be a healthy infant, it may take as much as it wants of it at each time of feeding. A robust infant will often take three pints, or even more, in the twenty four hours. In correcting the deficiency of the *carbohydrates* it is still a somewhat debated point whether milk- or cane-sugar should be employed. Dr. Jacobi strongly advocates the use of cane-sugar. Milk-sugar, he says, quickly ferments and is changed into lactic acid, any excess of which is peculiarly detrimental to infantile digestion, while cane-sugar is not so readily transformed. Professor Vaughan, on the contrary, thinks milk-sugar to be the more easily digested of the two. Malt-sugar, as found in foods prepared by Liebig's process, is, according to him, especially liable to undergo fermentation and produce irritation. In summer weather any excess of cane- or malt-sugar may prove decidedly laxative, and during that season special caution should be exercised in their use. Should either milk- or cane-sugar appear to disagree, it is advisable to have recourse at once to the other. I have frequently found a change in this way of service.

In reference to the amount of the *fats* Dr. Jacobi puts in a strong plea against allowing any excess of them to be present in our mixtures. He says that the infant intestine does not digest all the fat contained even in its mother's milk, and we ought not to increase the amount of the indigestible, appear to belong to them. In opposition to this, Dr. Rotch very pertinently remarks: "We have no right to conclude, from the fact that a certain amount of surplus fat is found in the napkins, that a small per cent. is sufficient for nutrition, or that a large per cent. will be thrown away by the infant." It is far more probable that nature introduces a certain per cent. of fat in human milk, with a purpose which can only be accomplished by that per cent.; and it will be an error on our part not to conform to her standard. My own experience coincides with that of many others, that young infants may often be fed, and will thrive, upon cream mixtures containing a fair percentage of fat, where other preparations have failed. Biedert says that while relatively small amounts of nourishment are sufficient for the good development of infants during the first few weeks of life, an increase in the amount of fat considerably above what is contained in dilute cow's milk mixtures, renders digestion easier, and increases the growth of the child. He has recommended the following schedule for the preparation of a food which varies according to the age and strength of the child:

	Cream.	Milk.	Water.	Milk-sugar.	Casein.	Fat.	Sugar.
					Per cent.	Per cent.	Per cent.
First month	125		375	15	1.0	2.5	3.8
Second month	125	60	375	15	1.4	2.6	3.8
Third month	125	125	375	15	1.8	2.7	3.9
Fourth month	125	250	375	15	2.3	2.9	4.2
Fifth month	125	375	375	15	2.6	3.0	4.3
Sixth month		500	250	15	2.9	2.3	4.1

A serious drawback in the employment of cream to any extent is the variability in its composition, and the difficulty of obtaining it fresh and good in a large city. For this reason Biedert has had compounded a cream preserve, which he has placed on the market, and which is much used in Germany. Monti and [illegible] speak very favorably of it.

Sterilization.—We have hitherto made but slight reference to the qualifications of freshness and absolute purity in cow's milk, but the great advantage of obtaining it in the country, night and morning, just fresh from the cow, free from the jolting incident to all means of transit, and from the impurities so apt to be associated with the different methods of storing it, has long been recognized by those who have had experience in infant feeding. That milk possesses to a high degree the property of absorbing gases and odors to which it may be exposed, is a matter of common observation, and recent medical literature abounds with instances where milk has acquired the infection of disease germs, and has thus become the means of communicating such disease to those who used it. Very recently, careful investigations have been made as to the presence of micro-organisms in milk, and their influence in producing the several changes which it undergoes. Dr. J. A. Jeffries, of Boston, one of the earlier workers in this field, writes: "It is a curious fact that, while adults are chiefly fed on sterilized food—that is, cooked food—infants are fed on a food peculiarly adapted by its composition and fluid state to offer a home to bacteria." On investigating the milk-supply of a city, it will be found to have an acid reaction, and to contain many growing bacteria. When kept for a day it becomes decidedly acid, has a sour taste, and is found to swarm with bacteria. Upon the character of the bacteria present will depend the character of the change that occurs—the milk-sugar may be turned to acid, the fats may be broken up, or tyrotoxicon or some other ptomaine formed. If fresh milk, however, be sterilized, and protected from germs, it undergoes no alteration, even after the lapse of long periods. These studies have advanced very greatly our knowledge of the causes underlying many of our failures in infant feeding. "Even when," says Dr. Jeffries, "we start with a food thoroughly the analogue of mother's milk, great care must be taken, or our enemy, the bacteria, will quickly invade the food, and, as if by the wave of a wicked fairy's wand, change the whole into a poison." Dr. Soxhlet, of Munich, starting with the principle advanced by Lister and Escherich, that milk in the glands in which it is secreted is aseptic, referred the introduction of the germs to the process of milking when the udders are imperfectly cleansed, or where the milking is performed in an atmosphere containing either putrefactive or pathogenic bacteria, as well as to absorption of impurities during storage or transportation. It is possible, also, that poisonous alkaloidal substances may be excreted in the milk when insufficient care is given to the feeding of the animal. The development and multiplication of these germs are much favored when the milk, after it is withdrawn from the udder, is allowed to remain at a somewhat elevated temperature. These fermentative changes are to be prevented by a sterilization of the milk, and the following method is proposed by him. Fresh milk is to be put into thoroughly cleansed flasks holding five or more ounces, which are closed with a rubber stopper, leaving beneath the stopper an empty space of the volume of several centimetres. Every rubber stopper has a central perforation into which a slender glass stopper may afterward be introduced. The flasks are then plunged up to the neck in a vessel of water under which an alcohol lamp is kept burning. When the water has reached the boiling point and the milk has risen sufficiently in the flask, the rubber stopper is secured by means of the small glass one. The water is then allowed to boil thirty minutes longer, and the milk is for that time under steam pressure at a temperature of 212° F., which will destroy all germs liable to produce fermentation. Milk so prepared will keep sweet for two or three weeks, and if the process be repeated a day or two after the first boiling, the length of time that it will keep is doubled. When the milk is to be used the bottle is put into hot water for a few minutes, the stopper is then removed and an ordinary nipple attached. It is then ready to be given to the child. Any milk remaining over after the child has fed should be thrown away. Dr. Caillé, experimenting with this method, obtained the following results: Milk heated in this apparatus for thirty minutes remained good for eighteen days. Milk boiled in small bottles for fifteen minutes, the bottles being closed before removal from the water either with rubber or with a plunger of cotton wool, remained good for five days. Milk boiled in a pot and after cooling put into small bottles which were then stoppered, became sour in four days. Milk boiled in a pot in the usual way and left standing in an open dish in an ice box: (A) ordinary store milk, turned after eighteen hours; (B) good bottle milk, turned after twenty-six hours. Dr. Jeffries prefers to steam rather than boil the milk. His apparatus is much simpler than that required by Soxhlet's method. The thoroughly cleansed flasks, from which the child is to be fed, may be first sterilized by heating them in an oven at a mild baking heat for thirty minutes, but this is not absolutely necessary. They are then filled with the food, stoppered with a plug of cotton wool, and steamed for fifteen or twenty minutes. Cotton wool, he says, forms the best stopper, as it cannot be blown out and is germ-tight. The steaming must be thorough, but any simple steamer, such as is used in ordinary cooking, will answer, provided it be filled with live steam. The vessel should be of good size, at least eight, or better twelve, inches across the bottom, and about sixteen inches high. A perforated false bottom should rest about four inches from the true bottom. The cover should be tight. When using it, two or three inches of water should be placed in the bottom and brought to a fast boil, when the flasks may be set as near the centre of the diaphragm as possible, the cover replaced, and the whole allowed to steam over a brisk flame for the requisite time. The flasks should then be taken out and placed on ice till required. When they are again to be gently warmed, the cotton plug taken out, and a clean nipple applied to the bottle. The milk should be as fresh as possible, and should be steamed as soon as received, else it may already be charged with the germs of decomposition.

The Milk-supply.—From these considerations there can be little doubt but that, when an infant is to be fed, the question of the milk-supply requires the careful investiga-

Artificial Feeding.

tion of the physician in charge. The milk should be procured with the utmost care and cleanliness, from properly fed and properly housed animals. The best animals to supply milk for children's use are not the high-bred Alderney or Jersey cows—which are very nervous animals, prone to tuberculosis—but the common red cow, which is quiet and gentle in disposition, a good feeder, and not excitable even in heat. It would be better that she should be stall-fed, but under all circumstances she should have access to abundance of clean water. The stall should be kept absolutely clean; the cow should never be milked when overheated; and the milker's hands and the cow's udders should be thoroughly cleansed before milking. No milk should be allowed from an animal not thoroughly healthy; from a cow shortly before, or shortly after, calving; or from one fed on distillery slops or brewery grains. Great care should also be taken to keep the milk in absolutely clean vessels, and to avoid jolting in its transportation. It should be at once strained and cooled to a temperature below 55° F.; should be kept in a room where the air is cool, pure, and free; and should never be delivered to consumers at a temperature higher than 60° to 65° F. No adulteration should ever be allowed, either by dilution, by antiseptics—principal among which are salicylic and boracic acids—by alkalies, or by the removal of fat. After standing it should show a minimum of twelve per cent. of cream. Professor Vaughan has recently shown that milk, under certain circumstances, may develop poisonous properties, due to the presence of a ptomaïne, which he has isolated and named tyrotoxicon. The conditions favoring its production are a comparatively warm temperature with the exclusion, or only limited supply, of air, and the presence of any condition of uncleanliness or impurity in the milk. It is apparently one of the diazo-benzol salts. In small doses it induces severe vomiting and purging, and in larger, great prostration, choleraic discharges, and death. Although this is the only ptomaïne so far isolated, yet it is probable that it is only one of a large class, owing their origin to fermentation and decomposition, and liable to be formed in infant foods. Hence the great necessity of careful sterilization by boiling or steaming. One of the most important advantages secured to breast-fed children, says Dr. Vaughan, arises from the lessened danger of their milk being infected with germs. These considerations have especial force during the more heated portion of the year, but at no time are they wanting in importance. And in the case of infants with weak digestion, it would appear very desirable that all milk used in their food should be sterilized as soon as received from the dairy; that no water, except such as has been previously boiled, should be employed, and that all prepared food should be boiled for a few minutes before it is given to the infant.

Milk from one Cow.—The propriety of obtaining milk from one cow is frequently urged by the laity. If the physician can be satisfied of the health of the cow yielding the milk, and of the way it is kept and fed, and if such milk be found to agree with the child, I think the method may have some advantages. In such cases the portion for the infant must either be taken always at the same period of milking, or from the contents of the pail after the milking is completed; otherwise it is liable to variation. It is very seldom that physicians can be sure of all these points, and therefore the ordinary mixed milk from a well-kept dairy is generally recommended as less liable to sudden change. In some instances it would appear that milk sufficiently pure and reliable for the use of infants cannot be obtained. Recourse must then be had either to one of the condensed milks, or perhaps to one of the patented infants' foods, of which we shall speak later.

Condensed Milks.—Condensed milk as a food for infants has both advocates and detractors. In the form of *fresh evaporated milk* (milk condensed without the use of cane-sugar), we think it may be of great utility, especially during the hot season. The heat employed during the earlier stages of its preparation has, by destroying any germs, removed the tendency to fermentation. The process of manufacture is said also to alter the casein, so that it coagulates in flakes not unlike those of woman's milk, and it is thus rendered easier of digestion. It keeps well for from two to six days. One part of it may be added to from seven to ten parts of water (Dessau recommends one to sixteen). To this it is advisable to add, especially when the dilution is with the larger amount of water, some fresh cream when obtainable, and some sugar of milk. Keating prescribes the following formula as making a preparation very nearly the equivalent of mother's milk:

Preserved milk	℥ j.
Water, previously boiled or filtered	℥ vij.
Fresh cream	℥ j.
Sugar of milk	℥ ss.

Dissolve.

The absence of cane-sugar in this preparation renders it valuable in summer in our large cities, when diarrhœa is prevalent. Under such circumstances it may sometimes agree better without the additional cream and sugar. Lime-water, or a decoction of barley or of flour, prepared by Dr. Smith's receipt, may take the place of pure water when deemed expedient. The ordinary canned condensed milk has the disadvantage of containing a large amount of cane-sugar, which is liable to disagree with the infant. When diluted with ten parts of water or more, as some recommend, it becomes deficient in the albuminoids and fat, and requires the addition of cream. It possesses the same advantages that the fresh preserved milk does, in being sterilized by the process it undergoes, and in the casein being rendered less coagulable, and, therefore, easier of digestion. The dilution may frequently with advantage be made with barley-water, or with the prepared flour; cream and a little salt should be afterward added. Owing to the large amount of sugar contained in it, there is said to be a tendency in babies fed upon it alone to develop fat quickly. Such infants are apt to be pale, flabby, and lethargic, and, although large, are generally far from strong, and frequently become rachitic. It may be of service, however, when not used for too long a time. Keating recommends its use in the case of young infants, and for such as are suddenly deprived of the breast, to tide over a short period till more perfect arrangements can be made. For older children, when combined with barley-water or dextrine, its use may occasionally be recommended. Should any symptoms of over-acidity of the stomach show themselves, it will be advisable to immediately make a change for another food.

Patented Foods.—When, for any reason, failure has attended attempts to feed the infant on a modified cow's milk, numerous patented artificial foods are placed at our disposal by interested agents, who loudly vaunt their special preparation as being the exact analogue of mother's milk, and the only food calculated to help the little one in its dire distress. We cannot deny that some of these are occasionally of service. It is desirable, therefore, that the physician should have some knowledge of their several properties and composition, further than the meagre and often incorrect statements contained in their advertisements. In all of these foods dependence is put, for the greater portion of the nourishment supplied, on the milk, which is either added by the user or previously introduced by the manufacturer. They are all, therefore, to be regarded as modifications of cow's milk; a fact which may explain the frequent successful results attending their use. With the exception of those which contain the milk in a condensed form, all, if administered alone, show a great deficiency in many of the most important ingredients of an infant food. The facts that they are secret preparations, over which, as physicians, we can exercise no supervision or control as to the amount of care, or to the quality of the material used in their manufacture; that analyses made by many able chemists have given very variable results, often differing widely from the manufacturers' published formulæ; that they are liable to be old and musty; and that for the poorer classes they are an expensive food without any corresponding advantages should, I think, make us resort to them with much caution. To the analyses of Dr. Leeds we are principally indebted for a knowledge of their more exact composition. He has grouped them all into three classes. The first class contains the farinaceous foods prepared from the flour of one or more of the cereals, with the starch generally slightly modified by baking. All of them yield a large proportion of starch to the acid solution, and for this reason are not suitable for infants under six months. None of them appears to possess any advantage over wheat flour, prepared according to Dr. Smith's formula, while in most of them the changes are much less complete. They are all liable to deterioration through long keeping. Among the best known of this class are the following: Imperial Granum, Blair's Wheat, Hubbell's Wheat, Hard's Food, Ridge's Food, Robinson's Patent Barley, Popeena and Bethlehem Oatmeal.

Leeds gives the following results of his analysis of these compounds:

Class I.—Farinaceous Foods.

	Blair's Wheat Food.	Hubbell's Wheat Food.	Imperial Granum.	Ridge's Food.	Robinson's Patent Barley.
Water	[illegible]	[illegible]	[illegible]	9.23	[illegible]
Fat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grape-sugar	[illegible]	[illegible]	none	[illegible]	[illegible]
Cane-sugar	[illegible]	[illegible]	none	[illegible]	[illegible]
Starch	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Soluble carbo-hydrates	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Albuminoids	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gum, cellulose, etc.	[illegible]	[illegible]	[illegible]		[illegible]
Ash	[illegible]	[illegible]	1.16	[illegible]	[illegible]

In the second class are placed all those in which the starch is to a great extent converted into sugar by malting, according to Liebig's formula. This method is thus described by Dr. Leeds: "Equal parts of wheat flour and barley malt, with a certain amount of wheat bran—added, it is said, for the sake of the inherent phosphates and nitrogenous matter—together with one per cent. of bicarbonate of potash, are mixed with sufficient water to make a thin paste. The mixture is allowed to stand at an ordinary temperature for several hours, and then heated to 150° F., until the conversion of the starch is completed. It is then strained, and the residue pressed and exhausted with water. The extract is evaporated in vacuo, at as low a temperature as is consistent with rapidity of working, dried at a higher temperature, and finally, by very skilful manipulation, brought to a finely pulverulent mass which does not contain sufficient moisture to cake. . . . The starch has thus undergone conversion into dextrine and grape-sugar, which, being soluble, pass into the liquid extract; but only that portion of the albuminous matter contained in particles so fine as to pass through the strainers, together with any soluble albumen (and this is specially valuable in the nutrition of infants), are found in the final product. If the virtue of Liebig's foods resides only in their not containing starch, but the products of it, together with sufficient bicarbonate of potash to make the reaction of the infant food like milk always alkaline, then so tedious and expensive a process should not have to be resorted to in order to obtain a mixture which can be made directly very cheaply. If, on the other hand, the other substances extracted from the grain have an important dietetic value of their own, analysis should be directed to ascertain their nature and amount." The principal foods of this class are Mellin's, Horlick's, Hawley's, Keasbey & Mattison's, and Savory & Moore's, for which I quote Dr. Leeds' analyses, and the Lactated Food, for the analysis of which I quote the results obtained by Dr. B. F. Davenport, of Boston.

Class II.—Liebig's Foods.

	Mellin's [illegible]	Horlick's Food.	Hawley's Food.	Keasbey & Mattison's.	Savory & Moore's.	Lactated Food.
Water	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grape-sugar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Cane-sugar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Starch	none	[illegible]	none	none	[illegible]	[illegible]
Soluble carbo-hydrates	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Albuminoids	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cellulose, gum, etc.					[illegible]	
Ash	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Milk-sugar						[illegible]

It will be noticed that the percentage of fat in all is extremely low, and that of grape-sugar very high. In Horlick's and Mellin's there is said to be no unconverted starch. Hawley's contains eleven per cent., while Savory & Moore's contains a large amount, as does also the Lactated Food. These foods, from the large amount of glucose they contain, are sometimes of service when the infant is of a constipated habit and suffers much from indigestion. If there be any tendency to diarrhœa they are liable to increase it. When a decided laxative effect is required it may be advisable to use them, without milk, for one or two meals in the day.

The *third* class comprises those foods to which the milk has already been added during the process of manufacture. Such foods are supposed, on the addition of water, to supply an infant food corresponding in nutritive value to human milk. All of them contain starch more or less converted into dextrine, together with condensed milk. Their mode of preparation insures more or less complete sterilization of the milk, and converts its casein into a very digestible form—important advantages during the summer season. Nestlé's is one of the oldest of these preparations, and is at present esteemed highly by many physicians. Very recently a New York firm has placed on the market a preparation which it terms Soluble Food. Dr. Earle mentions this food very favorably, and says that it is composed of forty-five per cent. powdered milk, forty-five per cent. dextrine, and ten per cent. milk-sugar. It is partly predigested, so that it should be easy of digestion. It is claimed that it approaches nearer to human milk in composition and digestibility than any other food in the market. My own experience with it has certainly in many instances been favorable. As in all of these foods the amount of fat is defective, it is better, when possible, to supplement it by the addition of a little cream. Of other preparations, Gerber's, Anglo-Swiss, and American Swiss are the best known. Dr. Leeds gives the following formula:

Class III.—Milk Foods.

	Nestlé's Food.	Anglo-Swiss.	Gerber's Food.	American Swiss.
Water	4.72	[illegible]	[illegible]	[illegible]
Fat	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cane-sugar	[illegible]	[illegible]	[illegible]	[illegible]
Starch	[illegible]	[illegible]	[illegible]	[illegible]
Soluble carbo-hydrates	[illegible]	[illegible]	46.78	[illegible]
Albuminoids	[illegible]	[illegible]	[illegible]	[illegible]
Ash	[illegible]	[illegible]	[illegible]	1.21

Dr. Rotch has prepared a table showing the ingredients of the several foods as usually given to the infant. A reference to the analyses of human milk, as given on the upper line, will show the errors in nutritive value and perhaps enable us to make any one of them correspond more closely to the standard. "All of these foods," he says, "are at times useful, provided we use them intelligently for the especial case; but for general use the patented foods should be avoided on account of the objections regarding their manufacture as a class. They are also the most difficult class of foods to make correspond with human milk. There is no reason why clinical results should not be much improved if physicians will only take time and trouble to approximate their artificial food to the natural aliment, and follow more uniformly nature's teaching.

*Comparison of Human Milk with Cow's Milk, and Cow's Milk Modified.**

		Reaction.	Starch.	Water.	Total solids.	Fat.	Albuminoids.	Sugar.	Ash.
Human milk		Alkaline	...	87.0	13.0	3-4	1-2	6-7	0.2-.4
Cow's milk		Acid	....	87.0	13.0	4.0	4.0	4.5	0.7
Cow's milk Water	1 2 — 3	Acid	....	95.61	4.39	1.33	1.33	1.5	0.23
Cow's milk Water	1 1 — 2	Acid	....	93.4	6.6	2.0	2.0	2.25	0.35
Condensed milk		....	....	28.0	72.0	10.0	10.0	50.0	2.0
Condensed milk Water	1 9 — 10	Neutral	....	92.8	7.2	1.0	1.0	5.0	0.2
Condensed milk Water	1 6 — 7	Neutral	....	89.66	10.34	1.45	1.45	7.14	0.3
Imperial Granum: Fat 1.01 Albuminoids 10.51 Sugar trace Ash 1.16 Starch 78.93 Milk Water	3 32 64 — 99	Acid	2.36	92.88	7.12	1.33 0.03 — 1.36	1.33 0.31 — 1.64	1.5 trace — 1.5	0.23 0.03 — 0.26
Mellin's Food: Fat 0.15 Albuminoids 5.95 Sugar 48.2 Ash 1.89 Starch present Milk Water	3 48 48 — 99	Acid	Present	91.74	8.26	2.0 0.004 — 2.004	2.0 0.17 — 2.17	2.25 1.44 — 3.69	0.35 0.05 — 0.40
Nestlé's Food: Fat 1.91 Albuminoids 8.23 Sugar 38.92 Ash 1.59 Starch 40.1 Water	1 10 — 11	Neutral	3.63	91.69	8.31	0.17	0.74	3.63	0.14
Barley-water: As usually made, with Robinson's barley, contains starch 1.4 Milk	1 2 — 3	Faintly acid	0.47	90.75	9.25	2.66	2.66	3.0	0.46
Meigs' Recipe: Cream Milk Lime-water Sugar-water	2 1 1 3 — 7	Alkaline	....	88.42	11.58	4.0	1.11	6.26	0.21

* The figures are approximate and represent general averages.

Amount to be Given.—Not only is the character and composition of the food itself of importance, but the amount to be given, and the times of giving it, demand the physician's careful attention. As Biedert remarks, the infant has no instinct which guards against overfeeding. Even breast-fed children are apt to drink too much, but those artificially fed have a much greater tendency to excess, since in general they obtain their food more quickly, and with less exertion on their part. The truth should be carefully impressed upon mother and nurse, that a bottle-fed infant thrives best upon the minimum amount of food necessary for development, whereas any excess tends to induce flatulence, to interfere with digestion, and, if continued, to unfavorably affect nutrition.

We have previously referred to the very rapid increase in the capacity of the infant stomach during the first two months of life, while in the third, fourth, and fifth months the increase is but slight. Corresponding with this fact, it would appear that while the amount of nourishment required during the first few days of life is but small, the quantity should be rapidly increased up till the end of the second month, when the increase may become more gradual. A considerable increase in the quantity needed usually takes place between the sixth and tenth months. Dr. Rotch quotes the results of Smitkin's investigations at the Children's Hospital in St. Petersburg, to determine the amount that should be given during the first few weeks of life. He finds that the greater the weight, the greater is the gastric capacity, and says that one one-hundredth of the initial weight of the infant should be taken as the starting figure for each meal, and to this should be added one gramme for each day of life. Thus considering 3,000 grammes as the initial weight, 30 grammes (about ℥ j.) will be required during the first few days, while by the end of the first month the amount required will be doubled. The following tables have been prepared by him to indicate the amount and frequency of feeding required. They should be regarded, however, as merely approximate, for infants, like adults, vary much both in their appetite and power of digestion.

Average Rules for Feeding.

The average initial weight of infants is 3,000 to 3,500 grammes (about 7 to 7½ pounds).

The average weight gain per day in the first 5 months is 25 to 30 grammes (about 1 ounce).

Age.	Intervals of feeding.	Number of feedings in 24 hours.	Average amount at each feeding.	Average amount in 24 hours.
1st week	2 hours	10	1 oz.	10 oz.
2nd–6th weeks	2½ hours	8	1½ to 2 oz.	12 to 16 oz.
6th to 12th weeks, and [illegible]				
[illegible]	3 hours	6	3 to 4 oz.	18 to 24 oz.
[illegible]	3 hours	6	5 oz.	30 oz.
[illegible]	3 hours	6	7 oz.	42 oz.

The weight, including the use of balances to determine the amount of each feeding at the beginning, [illegible]

[illegible]

	Each feeding.		
Initial weight.	[illegible]	1st 15 days.	15–30 days.
2,000 grms.	30 grms. = 1 ounce	[illegible] (about 1 oz.)	[illegible] (about 1¼ oz.)
3,000 grms.	[illegible]	[illegible] (about 1½ oz.)	[illegible] (about 1¾ oz.)
4,000 grms.	[illegible]	[illegible] (about 1¾ oz.)	[illegible] (about 2 oz.)

Directions for Feeding.—In bottle-fed infants regularity in the hours of feeding should be insisted on from the very beginning. The food should be given at about blood-heat (98°–100° F.) from a smooth glass bottle which has no corners that cannot be thoroughly cleansed. It is a wise precaution for the mother to taste each bottle to see that there is nothing amiss, and that the nipple is sufficiently pervious. Dr. Parker recommends a pure gum nipple with two holes as far apart as possible. Milk coming through one hole is not as comfortable to the infant as when it comes through two, and is more apt to induce attacks of choking. The infant should be fed lying in the nurse's arms with its head slightly raised, and its body in somewhat the same position as if it were being nursed at the breast. When it has finished nursing it should, if it be drowsy, be laid gently on its right side and allowed to sleep. Under no circumstances should it be tossed about or romped with shortly after it has had its food. The bottle, after the infant has finished nursing, should be at once removed, emptied, and cleansed; no playing with it by the child should be permitted. If any food remain in it unfinished, it must always be thrown away, for as the child draws milk from the bottle, the air which replaces the milk is that exhaled by the child, and would act quickly as a putrefacient. In selecting and ordering the food for an infant, it must always be borne in mind that no hard and fast rules are applicable to all infants. Careful watching is necessary to find out that the child thrives, that its flesh grows firm, and that it makes a reasonable gain in weight from week to week. Regurgitation, flatulence, hiccough, acidity of the stomach, constipation, or diarrhœa, with pains and the passage of curds or foul-smelling or clayey motions are all evidences of indigestion, and demand careful consideration and rectifying. The fæces should be carefully examined for abnormality and undigested materials. Occasionally superfluous fats resemble curds, and may be mistaken for them, but are at once detected by their solubility in alcohol.

Very early, in the case of immature and very sickly babies, and of infants with cleft palate, the ordinary feeding-bottle is inefficient owing to the infants not having power to suck. Feeding by spoon is slow and wearisome to the infant. In these cases Dr. Jarvis recommends the use of [illegible]. In this feeding-bottle simple pressure on the rubber piece, either by the lips or gums of the infant or on the exposed portion of the tube outside the bottle by the fingers of the nurse, will cause the food to escape from the bottle. Dr. Jarvis says that in many cases it has done good service. It can be obtained of surgical instrument dealers in New York.

Gavage.—Very recently Dr. Tarnier of Paris has advocated the method of gavage in infants prematurely born, or in such as are congenitally weak. The apparatus necessary for the purpose is very simple: a soft rubber catheter, No. 14 or 16 French, or a piece of gutta-percha tubing with a small glass receptacle of sufficient size to hold the amount of milk to be administered, attached to the distal end. The child is placed on the knee of the nurse with its head slightly raised. The tube is moistened with milk and introduced at the base of the tongue, and then very gently forced down the œsophagus to a distance of 15 ctm. The tube is then pinched between the two fingers, and the food is introduced into the receptacle. On relaxing the fingers and raising the receptacle the food flows gently into the stomach. Care must be taken to remove the tube gently and quickly; the infant must then be replaced in its warm cradle or couveuse. To the weakest infants eight grammes of food are given every hour. In spite of this feeding, the infant frequently loses weight for the first few days, but soon begins to gain steadily. Dr. Tarnier is said to have achieved marvellous results by this method.

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AUDITORY CANAL, ECZEMA AND DERMATITIS OF THE. Following an example set by the Editor of the REFERENCE HANDBOOK in his very practical treatise entitled "A Manual of Diseases of the Ear," I shall, in this article, make no attempt to draw a fine and accurate line of distinction between those acute and chronic inflammations of the skin lining the auditory canal which are clearly and unmistakably eczematous in their nature, and those others which, in greater or less degree departing from this standard, present rather the clinical features of a simple dermatitis accompanied by, or not accompanied by, consecutive inflammation of the underlying perichondrium and periosteum. Many of my readers have found, and others of my readers will surely find, that in practice the line of distinction between these two varieties of inflammation is often entirely undiscoverable, and that any attempt to lay down an infallible rule for its detection, based upon the varying classifications of writers on dermatology, will surely be misleading and in practice quite profitless, at least when they come to consider the subject of dermatology as applied to the external auditory canal.

A study of the subject of eczema as the disease affects any portion of the skin demonstrates the fact that under this title have been grouped together a great number of varying lesions, so that it is common to speak of the "protean aspects" of eczema. In the auditory canal so-called characteristic lesions of the disease are more commonly wanting than is the case in eczema of other regions; thus, for example, the vesicles of an acute eczema, a very helpful sign in diagnosticating the disease elsewhere, are almost never discoverable; and the subjective symptom of itching—considered so characteristic of eczema, although, of course, not pathognomonic of eczematous inflammation—while generally present, is, nevertheless, occasionally absent in what, but for this single exception, would be most manifestly an eczematous dermatitis of the canal. It becomes us to be careful how we give names to diseased conditions before we clearly understand what they are, lest we be misled by the very system of classification which is supposedly intended for our guidance. "Lucus a non lucendo:" let us beware lest we fail to see the wood, not indeed for the trees, but for the labels that a multiplicity of guides has tacked upon the trees.

There is, of course, such a thing as a well-marked eczematous inflammation of the auditory canal; as, for example, in the case of a suddenly occurring invasion of this region by a typical eczema which has spread from the auricle; or, again, in a case marked by the sudden onset of such a symptom as erythema, accompanied by slight burning pain and itching, and occurring in the auditory canal of a person in whom careful examination has demonstrated the absence of any form of otitis media on the one side, or of any affection of the skin covering the auricle or other parts of the body on the other, and where, moreover, the absence of any chemical or mechanical irritation of the skin surface of the canal can be positively proved. Undoubtedly, also, there is such a thing as a simple dermatitis of the canal, caused by chemical or mechanical irritation, and occurring in a person who has never given evidence of any tendency to eczematous or eczematoid inflammation of the skin. But between these two extremes lies an almost infinite series of gradations, and these middle-ground cases are the ones most commonly seen in practice. In a goodly proportion of such cases positive diagnosis between eczematous and non-eczematous dermatitis of the canal can only be made after a patient has been for some time under observation, long enough for his physician to have observed the tendencies of the disease rather than its precise local lesions; while in some instances, the physician never can say positively whether or not there be an eczematous element in the case.

When we come to consider what is, at least in our patients' estimation, the most practical aspect of the question under such circumstances, viz., the treatment of the disease, it is an undoubted fact that, so far as *local* measures are concerned, it makes no difference whether eczema be or be not the chief causative element in the case, provided that the idiosyncrasies of a typical eczema, during its earlier stages, in regard to the use of certain external applications (as notably water, strong preparations of tar, and strong irritants generally), be borne in mind, and that these idiosyncrasies be carefully respected in any doubtful case, the physician acting upon the assumption that such case is one of pure eczema.

Acute Eczema.—Acute eczema of the auditory canal may occur either as the extension of an acute or chronic eczema of the auricle, or as a purely local lesion. When occurring primarily and wholly within the auditory meatus, it is a rare affection, and the writer cannot remember at this moment having seen a single case of primary acute eczema thus limited in its area. As the extension of an eczematous inflammation previously existing upon the auricle, an acute eczema of the canal is by no means uncommon: as the exacerbation of a chronic eczematous dermatitis limited to the canal, it is of quite frequent occurrence: while a purely traumatic dermatitis of the canal, in a patient predisposed to eczema, is quite apt to present well-marked features of the eczematous process at some period of its course; possibly at the very beginning, in a striking disparity shown between the violence of the exciting cause and the resulting symptoms; possibly later on, by the manifestation of a special tendency to chronicity, by the production of an unusual degree of itching and a surprisingly protracted and abundant desquamation; or, it may be, finally, by yielding to treatment only after a course of internal medication, directed toward improvement of the gastro-intestinal and hepatic digestion, and, in this way, toward an elimination of imperfectly oxidized matters from the blood, has indirectly proved the existence of a so-called "gouty dyscrasia" to be a part cause, or a chief cause of the skin lesion.

The subjective symptoms of an acute eczema are pain in the ear, shortly followed by a diminution in the hearing power, and commonly followed by tinnitus, and by a feeling of fulness in the head. All of these, it will be noticed by the reader, are equally symptoms of an acute otitis media. How, then, may these two affections, in their incipient stage, be diagnosticated the one from the other? Such diagnosis based upon symptoms alone would be difficult in any case, impossible in many cases. Provided it was known that the patient had not previously been troubled by, or affected by, chronic eczematous dermatitis of the canal, the association of a sensation of itching with the four other symptoms just mentioned would justify the physician in suspecting eczema of the canal as the cause of all five symptoms; and if, in addition, he learned that the pain was of a burning or pricking character rather than lancinating, that it seemed to the patient to be very strictly limited to the ear, and not felt deeply within the head, or radiating widely from the ear, and that the hearing power was but slightly diminished, and the tinnitus not very annoying, he would have additional grounds for so suspecting.

The objective symptoms presented would be an erythema of the wall of the auditory canal, probably, but not invariably, involving its entire surface, and usually implicating the dermoid surface of the drum-membrane. But the examiner would be very apt to discover a degree of stenosis of the canal so great as to preclude a thorough inspection of its wall, and, in many instances, advanced to such a point as completely to prevent a view of its fundus, that is, of the membrane. At a very early stage of the process it might be possible to detect a vesicular lifting of the epidermal layer over some part of its extent (an appearance which the writer himself has never detected in eczema of this region, although he believes himself to have seen it in a case of impetigo contagiosa involving the canal lining). At a little later, although still a very early stage of the process, and perhaps within a few hours of its beginning, the walls of the canal might be seen to present a moist appearance, being already coated with the discharge,—at first serous, afterward sero-purulent, and perhaps profuse in amount,—which is exuded from the surface of the inflamed skin.

Such an examination as has been just indicated, if conducted by speculum, would be painful to the patient, perhaps intolerably so, and, therefore, not permitted; so that, for inspection of the canal, its partial straightening and dilatation by gentle traction on the auricle, would have to suffice the examiner, and by such examination he would, in most instances, be able to see but a short distance beyond the meatus. Nay, more, this very traction in itself would be apt to cause the patient pain; but, as a compensation to the examiner thus hampered in his investigation, it should be stated that *decided* pain resulting from gentle traction on the auricle is in itself an indication of inflammation seated in the auditory canal, although, of course, no proof of its being limited thereto; and that *extreme* pain on traction of the auricle is an indication rather of phlegmonous inflammation located *near the meatus*, and notably of furuncle, than a sign of an inflamed condition of the *inner* portion of the canal wall, whether existing independently of, or as secondary to, intra-tympanic inflammation. Such extreme pain attending traction on the auricle, added to the subjective symptoms of pain in the ear (especially if notably increased from the start by movements of the jaw in chewing), of slight deafness and tinnitus, and slight fulness in the head, and very often slight itching, should lead the examiner to search for prominent and tender spots near the meatus, and, at least for the moment, to suspect the existence of one or more furuncles as the sole cause of his patient's discomfort; and it would be only after excluding these that he could assume the existence of a more diffused and probably eczematous inflammation of the canal as its more probable cause.

Tenderness to pressure, made either in front of the tragus or close to the insertion of the auricle over the mastoid pressure exists in the former than in the latter affection, but possibly in both—is an objective symptom present in acute eczema when severe in its degree; present also in furuncle and other severe inflammations of the canal walls; and, as is well known, in severe intra-tympanic inflammations. The existence of swelling in front of, immediately below, or behind the auricle, common to all forms of severe inflammation within the ear, is yet oftener a symptom in extra- than it is in intra-tympanic inflammation; and, while in disease of the tympanum it is chiefly over the mastoid process that we expect to find the swelling, in inflammation of the canal walls we look rather to the skin area in front of the tragus, and to that lying immediately below the pinna, as likely to be the chosen seats of such swelling; and this is no wonder, as in inflammation of the canal walls it is rather an implication of the lymphatic vessels than of the periosteal covering of the temporal bone that is concerned as chief producing factor of the swelling. For the same reason it is found that the lymphatic glands lying over the mastoid, below the auricle, and over the parotid gland, are more apt to be involved in extra- than in intra-tympanic inflammation—a point that the physician will not infrequently find helpful in diagnosticating diseases of the ear, although it is one, among many clinical indications, the value of which he should aim rather to underestimate than to overestimate.

Probably enough has already been said regarding the early symptoms, both subjective and objective, accompanying an idiopathic acute eczema limited to the auditory canal, to show that the positive diagnosis of this affection, when seen for the first time within a day or two of its inception, is fraught with difficulty, and may be not only well-nigh, but quite impossible, and that in such cases it is only from the subsequent course of the disease that it can be positively identified. One means of diagnosis between the formative dermatitis of the canal and the acute otitis media for which it might be mistaken, would be the inflation of the tympanum by Politzer's method, or by catheter; and in very mild cases, accompanied by a slight degree of pain, or where an ocular examination of the membrana tympani being practicable, it is seen to occupy the normal plane and to be almost free from congestion, this procedure would be entirely justifiable. In such cases, however, it would almost never be necessary; as the examination by other means and notably by speculum, would have shown the disease to be clearly limited to the outer portion of the auditory canal. On the other hand, where stenosis of the canal rendered a good view of the membrane impossible of attainment, this very stenosis, coupled with the marked pain and unusually pronounced deafness and tinnitus, which together had led the physician to suspect the tympanic cavity as either the primary seat of the whole trouble, or at least as secondarily involved through congestion of its vessels, and that, too, in a marked degree, would, or should, forbid the inflation of the drum by any method as a means of establishing a more accurate diagnosis. The interests of the patient in such a case would not so emphatically demand an accurate diagnosis as to justify the risk of exacerbating a suspected otitis media by inflating the tympanum during its early and acutely painful stage; while the line of treatment to be adopted under such circumstances should be one equally suitable for an acute inflammation of the external, or for one of the middle ear, and harmful to neither. It may sound strange to some of my readers, but I make bold to say that, in a doubtful case of this kind, a paracentesis of the drum membrane, made despite the existing stenosis of the canal and without a view of the membrane previously obtained, and executed, as by skilled hands it could be even under such adverse conditions, in the hope of promptly relieving a severe otitis media whose existence was strongly suspected, would be far more justifiable than would be the tentative use of inflation as a means of diagnosis alone; while as a method of treatment simply, inflation, under such conditions, would be absurdly out of place, and would be dangerous to the patient. As the writer has already stated in his article on the examination of the ear (Vol. II. of REFERENCE HANDBOOK, p. 677), it is not admissible to inflate the tympanum by any method for diagnostic purposes when decided pain in the ear is present. It is true that very rarely, and under special conditions, the otological specialist may see fit to assume the responsibility, and the concomitantly involved risk, of violating a rule thus boldly expressed; but to all comers it may be added that the general practitioner will err on the safe side, and will thereby consult his own interests, if he keep the rule inviolate.

Treatment in this early stage of an acute eczema, as in the early stage of an acute otitis media, should be directed toward a relief of the congestion underlying the inflammation. Rest in bed, a mild cathartic, and the abstraction of blood by leeches or by the artificial leech, applied in front of the tragus, are the chief means to be used for this purpose. Pain, if severe, may be relieved by the application of dry heat to the affected side of the head, supplemented, if need be, by the internal or hypodermic administration of morphine, or of some other narcotic. Cocaine solutions, laudanum, almond oil, etc., should not be dropped into the ear.

This line of treatment is, of course, equally applicable to a primary and to a secondary acute eczema in its early stage. As soon as a discharge from the ear makes its appearance, it becomes necessary to resort to gentle syringing of the canal, more or less frequently repeated, in order to remove as quickly as possible the exuded secretion, which experience has proved to be more irritating to the inflamed skin than is the warm water employed for its removal.

Acute Eczema occurring in the course of Chronic Suppuration of the Tympanum, and the same occurring as the Exacerbation of a Chronic Dermatitis.—Acute inflammation of the auditory canal walls is, as is well known, no uncommon occurrence during the course of a chronic suppurative otitis media. Occasionally an unusual suddenness in onset and an unusual violence in the attack, and a disproportion between its violence and the degree of intra-tympanic inflammation, together with the appearance of a very profuse and greatly augmented discharge, the rapid involvement of the skin over the auricle and adjoining the same, and possibly the presence, synchronously, on some distant part of the body of a distinctively eczematous eruption, may combine to show the new symptoms to be due to eczema of the canal, rather than to any of the more serious conditions lying deeper within the ear, which are, indeed, in most cases and of [illegible], the underlying cause of such secondary trouble in the outer ear. An improper local treatment of the pre-existing chronic otitis media is often the exciter of this condition, and the writer recalls one instance, recently observed, where the insufflation of iodoform powder in a case of scantily discharging otitis media pretty evidently served, on two separate occasions, to excite a violent eczema of the canal and auricle in a little patient in whom other indications of a predisposition to eczema had been present. On both occasions the use of a mild mercurial cathartic, followed by a pretty free dosing with bicarbonate of soda for several days, and combined with the use of starch dustings of the acutely inflamed auricle, sufficed to check the severe symptoms and to cause a rapid disappearance of the complicating eczema. The extreme stenosis of the canal, and the great tenderness of its inflamed and swollen walls, almost entirely precluded the use of the syringe during these attacks, although both before and after their occurrence its employment had been found an indispensable element in the treatment of the discharging otitis media.

As already remarked, this occurrence of an acute eczema of the canal during the course of a chronic suppurative otitis media is a rare phenomenon in aural surgery. A far more common, and indeed the most common, method of occurrence is that in which an acute eczema suddenly supervenes upon, and appears as the exacerbation of, a chronic dermatitis of the canal. Under these circumstances, a valuable aid to diagnosis generally exists in the history of the pre-existing chronic affection. But this is not invariably the case, forasmuch as chronic dermatitis of the canal may exist for years without making its presence evident by symptoms which are annoying to the person affected; and this, of course, is particularly liable to be true in the case of a patient who is of a low order of intelligence, and of a disposition not easily affected by trifling symptoms.

In its method of manifestation such an acute eczema would differ little, if at all, from the primary form, or from that secondary to, and dependent upon, the chemical irritation produced by the discharge from an otitis media, or by the medicaments used in combating this latter; and the treatment of the condition would be the same in all three cases.

Chronic Eczematous Dermatitis.—And now, finally, we come to a consideration of that chronic inflammation of the skin of the external auditory canal, which is one of the commonest of those conditions which the aural surgeon is called upon to treat; a condition that, whatever be its exciting cause of origin, or whatever its method of manifestation, probably owes its existence, in the first instance, in a vast majority of cases, to a perversion in the constitution of the patient's blood, brought about by faulty elaboration of its constituents, and existing in what is known as the "gouty" or "lithæmic dyscrasia." The ill-understood condition of the nervous system known as "neurasthenia," may in some instances play the part of causative agent in initiating or maintaining this chronic dermatitis; but "neurasthenia," and that other and far commoner condition clinically recognized by all physicians, though accurately understood by none, and known as "struma," or the "strumous diathesis," are probably rather causative agents in the production of *acute* eczema of the canal, or of the acute *exacerbations* of a chronic eczema, than they are of a chronic dermatitis in this region which only occasionally, or it may be never, presents well-marked features of the typically eczematous process.

The rather common coincidence of a more or less distinctly eczematous dermatitis of the auditory canal, acute or chronic, with a catarrhal condition of the naso-pharyngeal mucous lining, has led some observers to suspect the existence of a "reflex" connection of cause and effect between the throat lesions and those in the ear; and such a relation between the two sets of lesions and symptoms cannot be positively denied; yet to the writer it appears equally reasonable to assume that in such a case the pharyngeal and aural troubles are simply coincident, and that both are equally the secondary manifestations of an underlying dyspeptic or "gouty" poisoning of the patient's blood.

A like relation, and one seemingly of a more indisputably "reflex" nature, subsists between dermatitis of the auditory canal and functional or pathological disturbances in the uterus and ovaries; for it is a matter of common observation among aural surgeons that this form of aural disease is of frequent occurrence in women affected with disturbance in these distant organs, and particularly in those reaching the menopause; and that in such cases the aid not only of the family physician, but occasionally also of the gynecologist, is demanded for the radical and permanent cure of the obstinately recurring aural affection.

In chronic eczematous dermatitis there is seldom or never a profuse fluid excretion, the presence of an abundant discharge generally signifying an exacerbation of the disease. The discharge, when present, may be serous, sero-sanguineous, or sero-purulent in character; is intermingled with a greater or less quantity of desquamated epithelial scales, and is apt to have a bad odor of a peculiarly pungent character, and different from the equally disagreeable smell of a discharge originating in, and proceeding wholly from, the tympanum. The desquamative process is always present in greater or less degree; sometimes evidenced only by a furfuraceous coating of the canal wall, which in such cases may be slightly congested, or may appear of the normal color; sometimes shown in a shedding of veritable sheets of skin which may be superimposed and packed together so as to form a dry occluding plug; sometimes shown in the presence of a blotting-paper-like mass of mingled epidermis and foul pus or sero-pus, so as to form a moist occluding plug. The walls, more or less congested, are often considerably thickened as the result of the chronic dermatitis itself, or of the latter combined with the thickening left by intercurrent attacks of periostitis and perichondritis; and of course, from such thickening there results a stenosis in the calibre of the canal. This thickening of its dermal wall, involving the outer surface of the drum-membrane, leads to decided impairment of the hearing-power, an impairment increased of course by obstruction of the canal calibre from an epidermal plug when such is present, further increased by the stenosis of the canal where this exists, and, as in the case of a transient acute inflammation of the canal lining, dependent also in part upon a secondary congestion and thickening of the tympanic mucous membrane, or upon the presence within the tympanum of an effusion from its walls thus secondarily involved in the inflammatory process.

From what has just been said, the reader will naturally and properly infer that a *marked degree* of deafness is characteristic rather of a chronic dermatitis than of an acute eczema of the auditory canal. From what was said shortly before concerning the common coincidence of naso-pharyngeal catarrh with external otitis, he will with equal propriety infer that the intra-tympanic factors of such deafness may, in the case of both acute and chronic otitis externa, be equally or more dependent in origin upon the pharyngeal lesions than they are upon those co-incidentally existing in the external auditory canal.

Among the rarer phenomena attendant upon a chronic dermatitis of the canal is the appearance of polypoidal growths springing from some point of the canal wall, and owing their origin to the supervention of actual ulceration of the wall or of localized necrosis of the underlying bone. It is probable that the presence of fungous growths in the ear is as frequently due to a chronic dermatitis as it is to any other cause; the sporules of these fungi lodging and finding a soil suited to their growth in the scantily secreting lining of the canal, just as they do occasionally in the similarly secreting lining of the tympanic cavity during the late stage of a diminishing purulent inflammation of this cavity. This condition, which is to be regarded as rather an accidental complicating symptom than as a self-existing disease, will be found fully discussed under the heading of "Parasitic Inflammation of the External Auditory Canal," in Dr. Frank Buller's article describing the congenital defects, diseases, and injuries of that canal (Vol. I. of this REFERENCE HANDBOOK, pp. 420 and 421). No better means exists for the destruction of these growths,—at least where they are confined wholly to the canal, and probably also in most other cases,—than the nitrate of silver treatment, presently to be mentioned as a leading remedy in combating the external otitis they so commonly accompany. In certain rare instances the long persistence of a chronic suppurative otitis media, resulting in extensive destruction of the membrana tympani, and a subsequent covering of the exposed tympanic wall by cicatricial membrane, appears, as it were, to convert the exposed portion of the tympanic cavity thus lined with epithelium into the inner extremity or fundus of the auditory canal, and to give rise therein to a very persistent form of desquamative dermatitis of its wall. This condition may be regarded either as a desquamative inflammation of the tympanum, or as a deep-seated inflammation of the wall of the external auditory canal, to which this cicatrized portion of the tympanum has been added as a sort of pathological annex. The freeing of such a deeply lying and irregularly shaped cavity from the dense plug of epithelium, more or less mixed with pus, that in certain cases tightly occludes it, is a task of no little difficulty. One case of this kind, in which it seemed that a distinctively eczematous element entered into the nature of the pathological process, and where several fragments of wood were discovered beneath the occluding plug, has been briefly described by the writer in his article on "Foreign thelium in the Tympanum" (HANDBOOK, Vol. VII., p. 480).

A somewhat similar case, but one in which the intra-tympanic space is almost exclusively involved, is at present under the writer's observation at the Vanderbilt Clinic. The analogy existing between the condition in which, from chronic desquamative inflammation, the auditory canal becomes occluded with a laminated plug of epithelium more or less mingled with [illegible] ("keratosis obturans"), and the so-called "cholesteatoma" of the tympanum of [illegible] intra-tympanic origin, has been pointed out by Dr. Burnett in the article already cited (Vol. I., p. 426). The process is the same in both instances, and some of these cases appear to lie in the borderland between a pure and it may be a primary external otitis and that form of otitis media characterized by the accumulation of a considerable mass of inspissated pus and caseous matter in the tympanic vault and antrum, which leads ultimately to mastoid sclerosis.

The treatment of chronic dermatitis of the auditory canal may be divided into two heads, comprising, respectively, the constitutional treatment of the dyscratic condition, or of the "lithæmic dyscrasia," the "strumous dyscrasia," or state of malnutrition,—one or the other of which will almost always be found to underlie the local pathological processes in the ear,—and the purely local treatment of these local lesions. Of these two lines of treatment, the former demands no special discussion in this place; concerning the latter, it will be proper to say a few words before bringing our article to a close.

Except during the acute exacerbations of the disease, whose treatment has already been sufficiently indicated under the heading of "Acute Eczema," no better local application for controlling the inflammation can be found than is the filling of the canal, from time to time, with solutions of nitrate of silver, varying in strength from 30 to 180 grains to the ounce. The method of employing such a solution is as follows: The canal should first be, so far as possible, cleansed of pus and epithelium by syringing with warm water. It should then be dried with absorbent cotton. Next, the patient being directed to lay his head on a table, so as to bring the axis of the canal to a vertical position, the physician should fill the canal with the solution by means of a dropper. The patient is then told to report to the operator as soon as he experiences a sensation of heat in the filled ear, and directly he so reports, the solution is to be immediately syringed out again with warm water. The canal is then dried once more, and then thoroughly smeared with vaseline, or borated vaseline, or weakly carbolized vaseline, and the operation is done. Such an application may be made once a week, or once in every ten days in the less severe cases; twice a week in those of greater severity. The strength of the solution selected should be in inverse ratio to the amount of congestion and the amount of fluid discharge present, and of course especial care is to be taken, in regard to the use of the stronger solutions, where a perforation of the membrana tympani is seen, or where its existence is suspected. The benefit derivable from applications of this sort is often simply surprising, even in the most inveterate cases the annoying itching being sometimes greatly allayed and the hearing power greatly increased by a single application. During the intervals between the applications the patient should be directed to syringe the ear as little as may be consistent with a proper freeing of the canal from a still persisting discharge, and should be directed to instil into the ear from time to time some five or six drops of vaseline oil, to which may be added (in cases where the itching is very annoying, or the desquamative tendency of the process especially marked) either oil of cade in the strength of one drop to the drachm, or carbolic acid in the strength of from one to three drops to the ounce.

For the removal of occluding plugs, simple syringing with warm water will frequently be found insufficient, and the physician may find it necessary to resort to the use of the blunt curette, probe, hook, and angular forceps, alternating such use with repeated syringings. And not infrequently, it is only after a succession of attempts thus made on different occasions, that the canal will be sufficiently cleared to permit a reaching of its entire wall with the silver fluids and emollient applications just described. The addition of bicarbonate of soda to the water employed in syringing will occasionally prove serviceable as tending to soften the hard epithelial mass.

Huntington Richards.

AUSTRALIA. Forasmuch as the only portions of the Australian Continent hitherto considered, or ever likely to be considered, suited to the residence of invalids, have been already discussed in the articles entitled Melbourne, New South Wales, and Victoria, and inasmuch as any account of the purely intra-tropical climate of Northern Australia, or of the peculiarly dry and "extreme" climate of the great inland basin (beyond such data as have been already elsewhere presented), would be out of place, no attempt to present additional information respecting the meteorology of Australia, taken as a whole, will be made; and the writer, having departed from his original intention of presenting such information in a general article on Australia, and having devoted up so much of this general information as properly belongs within the pages of a purely medical work between the three articles already cited, now begs to refer readers of the HANDBOOK to those articles.

H. R.

BADEN is a small town of about 4,000 inhabitants, in the Canton of Aargau, or Argovie, Switzerland, in which are numerous thermal springs. The town lies at an elevation of 1,250 feet above sea-level. There are twenty or more springs, having a temperature of from 116° to 120° F., of which the best known are the Limmat, the Heisserstein, and the Sainte Vérène. The composition of the last-named spring, computed in grams per litre, is as follows (Müller):

Sodium chloride	[illegible]
Calcium chloride	[illegible]
Magnesium chloride	[illegible]
Calcium sulphate	[illegible]
Strontium sulphate	[illegible]
Sodium sulphate	[illegible]
Potassium sulphate	0.127
Magnesium carbonate	[illegible]
Silicic acid	[illegible]
Manganese, bromide and iodide, [illegible]	[illegible]
Total	[illegible]

The waters are employed chiefly in the form of douches and baths, and are taken internally only in certain cases. The principal indications for these waters are gout and rheumatism, lead poisoning, chronic catarrhal inflammation of the respiratory passages, certain forms of neuralgia, and skin diseases in rheumatic and gouty subjects.

The bathing season proper extends from May to October, but the resort is visited more or less during the entire year. The number of guests at Baden is estimated at from 15,000 to 20,000 in the course of the year.

T. L. S.

BADEN-BADEN, so called to distinguish it from the other Badens, is one of the oldest and most celebrated of the German spas. It is a city of some 15,000 inhabitants, in the Grand Duchy of Baden, situated at the northern extremity of the Black Forest, at an elevation of 660 feet above the level of the sea. The climate is mild, rather moist, and free, as a rule, from sudden changes of temperature. The average temperature for the spring months is 47.4° F.; for the summer, 62.9°; for the autumn, 48.6°; and for the winter, 34°. On account of its equable climate the resort is frequented throughout the year by many sufferers from rheumatism, and serves as a resting place in the spring and fall for patients with pulmonary disorders travelling from and to Meran and other winter resorts.

There are very many thermal springs at Baden-Baden, which, however, differ but little among themselves in the relative proportions of mineral constituents. The most important springs are the Hollenquelle, Judenquelle, Ungemachquelle, Brühbrunnen, and Kühlerbrunnen. The waters from these springs are brought to a common reservoir and thence distributed through pipes to different establishments in the city. There is a separate reservoir for the water of the Ursprung, but it is generally mixed with the rest in its distribution throughout the city. The principal constituents of the water of the Ursprung, and their amount in parts per thousand, are, according to the most recent analysis by Bunsen, as follows:

Sodium chloride	2.151
Potassium chloride	0.163
Calcium carbonate	0.165
Calcium sulphate	0.202

In some of the springs Bunsen has recently found lithium chloride in the proportion of 0.0295 to 0.0306 Gm. per litre. The temperature of the different springs varies between 149° and 155.5° F.

All of the alleged therapeutic methods commonly used at the German spas, mud-baths, douches, herb-juice baths, milk-cure, whey-cure, grape-cure, etc., are carried out at Baden-Baden. The summer season extends from the beginning of May to the end of October, but, as mentioned above, the resort is frequented more or less during the entire year.

The principal diseases for the relief of which a course of the waters at Baden-Baden is recommended are gout, rheumatism, paralyses, and various affections of the nervous system. Recently it has become fashionable to send here patients with skin diseases or disorders of the digestive system, and women with affections of the reproductive organs. On account of the mild and equable climate many sufferers from pulmonary affections, and convalescents from acute disease, often derive considerable benefit from a residence of longer or shorter duration at this resort. Many others visit Baden-Baden merely for pleasure. *T. L. S.*

BADEN-BEI-WIEN, so called to distinguish it from other places on the continent of Europe having the same name, is a watering-place in Austria, and a popular summer resort for the Viennese. There are upward of thirteen thermal springs here, with a temperature ranging from 77° to 97° F. The water is clear as it emerges from the ground, but becomes turbid on exposure to the air, and possesses a strong odor and taste of sulphuretted hydrogen. The waters are used, as a rule, only for bathing purposes, that of the Ursprungsquelle, or Römerquelle, however, being also employed internally in certain cases, usually mixed with milk, or whey, or with other mineral waters. The principal constituents of this spring, according to an analysis by Keller, are as follows: One litre contains of

	Grams.
Calcium sulphate	0.3458
Calcium carbonate	0.3387
Sodium chloride	0.0670
Sodium carbonate	0.0064
Sodium sulphate	0.1882
Potassium sulphate	0.0640
Magnesium chloride	0.0500
Magnesium sulphide	0.0016
Silicic acid	0.0020
Organic matters	0.0013
Total	1.0650

The gases are carbonic acid, nitrogen, oxygen, and sulphuretted hydrogen.

The baths of Austrian Baden are recommended for those suffering from the so-called scrofulous troubles, chronic respiratory catarrhs, chronic rheumatism and gout, and some forms of sluggish skin diseases.

Baden-bei-Wien lies on the eastern slope of the Alps, at an elevation of a little over 700 feet above sea-level. The climate is fresh and invigorating, but sudden changes of temperature are not uncommon, necessitating caution on the part of those suffering from affections of the respiratory organs. The resort is visited the year through, but is naturally more frequented during the summer season, which extends from the first of May to the middle of October. *T. L. S.*

BAGNÈRES-DE-BIGORRE, or Bagnères-sur-l'Adour, is a thermal station in the department of the Hautes-Pyrénées, France. It is a little town of some 10,000 inhabitants, situated in the valley of the Adour, on a sheltered slope of the mountain, at an elevation of 1,900 feet above sea-level. The climate is mild and not subject to very great or sudden variations of temperature. There are some forty chalybeate springs here, having a temperature ranging in the different springs from 68° to 149° F. The following is the composition of two of these springs, according to analyses by Ganderax, computed in grams per litre:

	Source de la Reine.	Source du Dauphin.
Sodium chloride	0.062	0.040
Magnesium chloride	0.130	0.104
Sodium sulphate	0.396	0.400
Calcium sulphate	1.680	1.900
Magnesium carbonate	0.044	0.119
Calcium carbonate	0.206	0.142
Ferrous carbonate	0.080	0.114
Silicic acid	0.036	0.044
Organic matters	0.006	0.017
Loss	0.054	0.020
Totals	2.751	2.900

These waters are used internally and in baths in the treatment of anæmia and chlorosis, intestinal sluggishness occurring as a result of a sedentary life, hepatic congestion, etc. Bigorre is a favorite summer resort for Parisians, and the accommodations for guests are excellent. *T. L. S.*

BAGNÈRES-DE-LUCHON is a small town in the department of the Haute-Garonne, France, not far from the Spanish border. It lies in a valley of the Pyrenees, at an elevation of about 2,000 feet above sea-level, and the climate, though rather mild, is subject to sudden and wide variations of temperature. There are forty-nine thermal sulphur springs in the place, the temperature of which ranges from 61° to 154.5° F. The following is the composition of the Source de la Reine, according to an analysis by Filhol. One litre contains of

	Grams
Sodium sulphide	0.0508
Iron sulphide	0.0022
Manganese sulphide	0.0028
Copper sulphide	trace
Sodium chloride	0.0624
Sodium sulphate	0.0212
Potassium sulphate	0.0092
Calcium sulphate	0.0312
Sodium silicate	trace
Calcium silicate	0.0102
Magnesium silicate	0.0048
Aluminum silicate	0.0255
Silicic acid	0.0299
Total	0.2512

The gases are oxygen, nitrogen, and sulphuretted hydrogen. The temperature of the water is 132.4° F.

The waters of the Luchon springs are employed internally and externally in the treatment of rheumatic and gouty affections, caries and necrosis, various skin diseases, chronic mercurial poisoning, syphilis, etc.

Luchon is the most celebrated of the many springs in the Pyrenees, and is visited by upward of 20,000 persons during the season, which extends from the middle of June to the middle of October. *T. L. S.*

BRAIN. GROSS OR MACROSCOPIC ANATOMY.—§ 1. *Scope of this article.*—The histological, physiological and surgical aspects of the brain are discussed elsewhere in this and in preceding volumes; here, therefore, the organ will be considered mainly from the morphological stand-point.

§ 2. The liberal provision of the publishers for illustrations has rendered it possible to compose the text largely of commentaries upon the points illustrated by the figures. Of the 105 figures, 80 represent preparations made by the writer for the museum of Cornell University;* these preparations are designated by their analogous members; the drawings have been executed, from the specimens and from photographs, by Professor R. C. Carpenter (C.), Mrs. S. H. Gage (G. or S. P. G.), and Mrs. Wilder (W.). The 13 borrowed figures are credited to their sources. The remaining illustrations are original diagrams.

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* The writer desires to acknowledge his indebtedness for material and assistance to many students, past and present, and especially to his colleague Professor S. H. Gage, whose suggestions also have been of great value.

§ 2. Points relating to the brain illustrated upon Figure 1.—A. The relative location and extent of the cranial and hemal regions of the head so far as they appear at the meson.

B. The continuity of the two portions of the neuraxis, the myel ("spinal cord"), and the brain (encephal), or at least the junction of the cranium with the spine.

C. The impossibility of determining the exact limits of these two neuraxial regions, since they pass insensibly the one into the other.

D. The obvious subdivision of the brain into several regions represented, for example, by the cerebellum, the cerebrum, and the intervening narrower part, which is sometimes called *isthmus encephali*.

E. The impossibility of determining the precise limits of these regions since they are continuous, and do not present either articulations or joints as with the skeletal segments.

F. The possibility of recognizing in the adult brain five divisions or segments of encephalic cavities corresponding with the five embryonic encephalic vesicles and with the divisions of more nearly equal size in certain other vertebrates.

G. The convenience of indicating the approximate boundaries of these segments by lines.

H. The representation of each segment at the meson by some well-known part; the metencephal by the postoblongata; the epencephal by the cerebellum and pons; the mesencephal by the crura and geminal lobes; the diencephal by the thalami, conarium, and hypophysis; and the prosencephal by the cerebrum.

I. The existence in each of these segments of a cavity which communicates with the adjoining cavities, the whole series being apparently an enlarged continuation of the myelic canal.

J. The insignificance of the mesal cavity of the prosencephal as compared with not only the other cavities but the cerebrum itself.

K. The presence of an orifice, the porta ("foramen of Monro"), evidently leading lateral from the mesal aula into a cavity within the right hemicerebrum.

L. The relations of the masses to the cavities, as are related the floors, roofs, and side-walls of an edifice to the apartments.

M. The great difference in the thickness of the roofs and floors at different points.

N. The continuity of the side-walls, floors, and (except at one point) of the roofs.

O. The existence of certain fibrous masses, commissures, extending across the meson, and therefore divided in this preparation.

P. The existence of a subspherical appendage of the base of the brain, the hypophysis, in a deep pit in the floor of the cranium (the "pituitary" or hypophyseal fossa).

Q. The change in direction of the cranial floor at about this point, the remnant of the embryonic cranial flexure.

R. The similar angle formed by the base of the brain.

S. The still more decided angle formed by the general outlines of the floors of the encephalic cavities at a point nearly corresponding with the cephalic end of the mesencephalic cavity.

T. The liability of misapprehension from the employment of the ordinary descriptive terms, *anterior*, *posterior*, *superior*, *inferior*, upper, and lower; since each of these terms would have one meaning for the myel and postoblongata, and another for the diencephal. It is as if two adjoining houses faced, one to the east and the other to the south; the employment of *front* and *back* as designating structural features of the two would necessarily lead to misapprehension.

U. The convenience of regarding the entire floor as ventral, the entire roof as dorsal, any region of the brain nearer the myel as relatively caudal, and any region farther therefrom as relatively cephalic.

V. The dorsal expansion of most of the segments. The wedge-like shape of the mesencephal is easily recognized; the thalami are not wholly exposed, but the region is more extended dorsally than ventrally; the cerebellum is much larger than the pons; while the disproportion of the cerebral hemispheres to their strictly basal, mesal part, the aula, is one of the many remarkable features of the adult human brain.

W. The tendency of certain segments to overlap adjoining parts, especially in the caudal direction; see §§ 29 and 41.

X. The lack of exact collocation between the encephalic regions and the cranial bones; the cerebellum corresponds to less than half of the supraoccipital bone, and extends a little beyond its margin at the *foramen magnum*.

Y. The connection of the lambdoidal suture with the dorsal end of the occipital fissure, and the location of the dorsal end of the central fissure nearly dorsad of the splenium, the caudal margin of the callosum.

Z. The location of the mesal craniometric points, nasion, bregma, lambda, and inion.

§ 4. Order of Treatment.—I. Introduction, §§ 1-5.

II. General constitution of the brain, segments, etc., §§ 6-61.

III. The metencephal (postoblongata), §§ 62-74.

IV. The epencephal (preoblongata, cerebellum and pons), §§ 75-93.

V. The mesencephal (gemina and crura), §§ 94-104.

VI. The diencephal (thalami), §§ 105-117.

VII. The prosencephal: *a*, the cavities; *b*, the parietes; *c*, the commissures; *d*, the fissures; *e*, the gyres; *f*, brain weights, etc., §§ 118-289.

VIII. Bibliography.

§ 5. *Method.*—What seem to the writer the more important facts and fundamental ideas respecting human encephalic morphology are stated in a series of propositions, brief and direct, and numbered for ready reference. Unless otherwise stated, these propositions apply to the human brain, and may not always hold good for those of other vertebrates, or even other members of the mammalian class. Few now question the advantages of dissecting more available animal brains as a preparation for work upon the human organ; the use of animal brains will be considered in the article **Removal of the Brain**. From their simplicity, also, or their smaller size, or because they emphasize some particular feature, the brains of certain animals may profitably be studied before or in connection with that of man; but the writer deprecates the extent to which merely curious or startling details of comparative anatomy are sometimes introduced into medical publications, and has here confined himself as closely as possible to the human structure; see his previously expressed opinion on this point (*New York Medical Journal*, October, 1877). Most of the statements are parts of common anatomical knowledge, and special references are seldom given. In this connection, therefore, the following extract from the preface to Huxley's "Anatomy of Vertebrated Animals" may be appropriately added:

"The reader, while he is justly entitled to hold me responsible for any errors he may detect, will do well to give me no credit for what may seem original, unless his knowledge is sufficient to render him a competent judge on that head."

§ 6. Prop. I. *Definition.*—The *brain* (Gr., ἐγκέφαλος; Lat., *cerebrum*; late Lat., *encephalon*; It., *cervello*, *cerebro*; Sp., *cérebro*; Fr., *cerveau*; Ger., *Gehirn*; Eng., *encephalon*, *encephal*) is the enlarged, segmented, cephalic ("anterior") portion of the neuraxis (nervous axis, cerebro-spinal axis, central nervous system, myelencephalon, neuron, etc.).

For common equivalents of vernacular terms see the Index. For considerations in favor of the terms herein employed, see the article **Terminology, Anatomical**, in this volume.

§ 7. Prop. II. The brain is but one of the three great mesal (median) organs which is nearest the dorsal surface of the body, and farthest from the heart; Fig. 4685. The other two are the *enteron* (alimentary canal; Fig. 4685, *œsophagus*, and the *axon* (skeletal or body axis; notochord in early embryos, but in later stages and adults the series of centrums or bodies of the vertebræ), Fig. 4684, *odontoid process*, etc. The enteron is in the ventral (hæmal) cavity; the neuraxis occupies the dorsal (neural or cerebro-spinal) cavity; the axon forms a partition between the two.

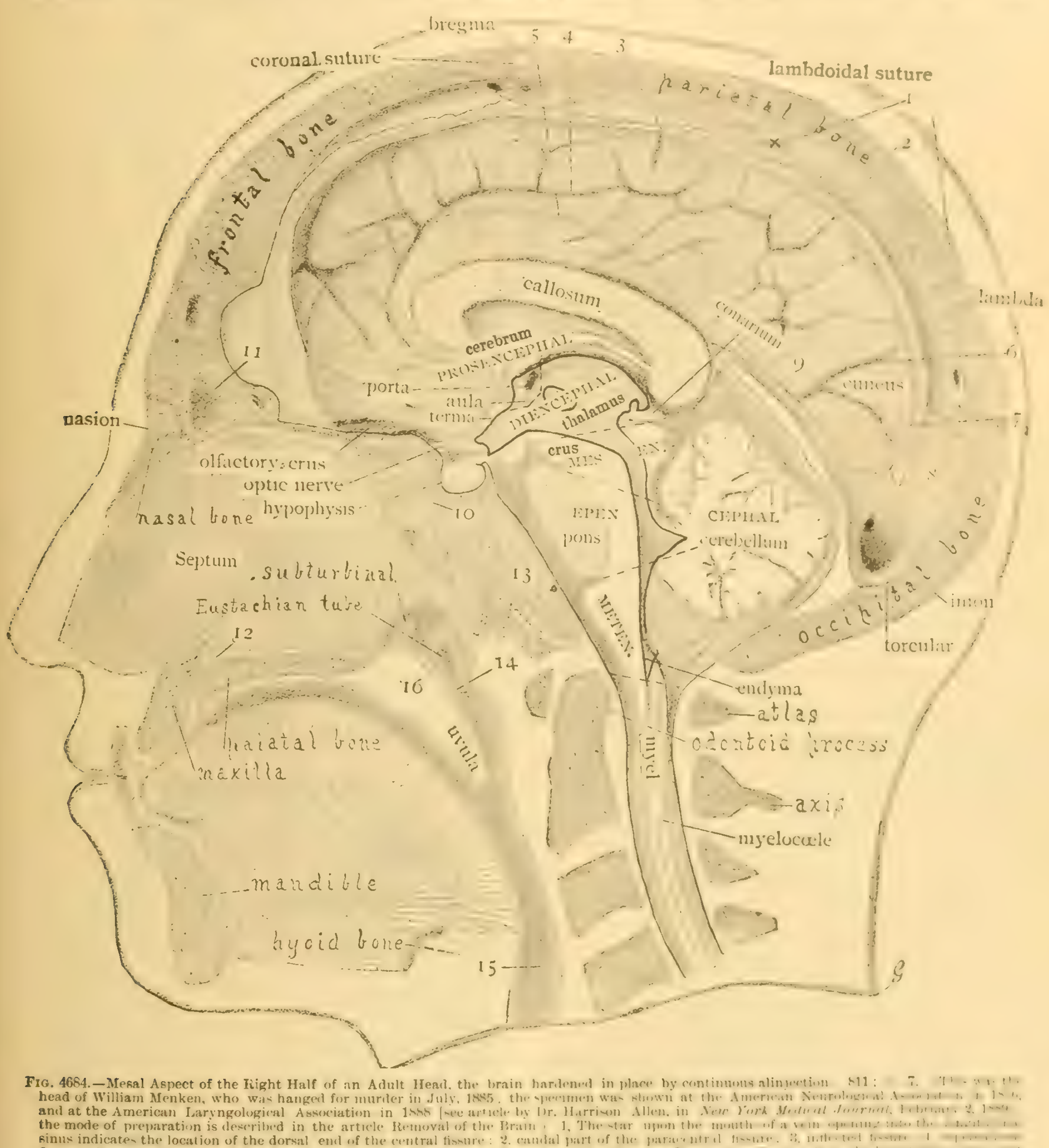


FIG. 4684.—Mesal Aspect of the Right Half of an Adult Head, the brain hardened in place by continuous alinjection (§11 ; [illegible] 7). This was the head of William Menken, who was hanged for murder in July, 1885; the specimen was shown at the American Neurological Association in 1886, and at the American Laryngological Association in 1888 [see article by Dr. Harrison Allen, in *New York Medical Journal*, February 2, 1889; the mode of preparation is described in the article Removal of the Brain]. 1, The star upon the mouth of a vein opening into the [illegible] sinus indicates the location of the dorsal end of the central fissure; 2, caudal part of the paracentral fissure; 3, [illegible] fissure; 4, [illegible] fissure; 5, callosal margin of the falx, indicated by the interrupted line; 6, occipital fissure; 7, calcarine fissure; 8, in the [illegible] dorsad of the torcular; 9, tentorial sinus; 10, a sphenoidal sinus (not vascular, but a cavity in the sphenoid bone); 11, a frontal sinus; 12, [illegible] palatine canal; 13, basioccipital bone; the basisphenoid has 10 upon it, but the two bones are continuous; 14, naso-pharynx; 15, [illegible]; 16, soft palate.

Defects.—The planes of section of the brain and of the other parts are not absolutely identical, although perhaps nearly enough so for most purposes. The section-plane, as made by the saw, passed just sinistral of the meson so as to leave attached to the right half the [illegible] septum, the latter scored slightly in its cephalic part; the preparation was photographed in this condition, but later the [illegible] excepting along the longitudinal sinus, so as to expose the fissures; then the various parts that cross the meson (callosum, fornix, [illegible]) were gradually pared down until the exposed surfaces were very nearly mesal; the changes in these parts were so slight that the [illegible] photograph served to locate all the parts; the fissures, however, were drawn from measurements of their relative distances. [illegible] and all the soft, vascular parts are swollen by the alinjection; the margins of the tongue are moulded upon the teeth; [illegible] wall of the pharynx are obviously thickened, and the subturbinal projects beyond the true margin of the septum; [illegible] perhaps the case temporarily during the congestion attending a severe "cold in the head." No attempt has been made to [illegible] the structure of the skin, the exact direction of the lingual muscles, or the details of the nuchal region. As a whole, the present figure is intended to serve mainly as a diagram, and the specimen will be more completely described and figured hereafter. See § [illegible].

§ 8. Points Illustrated by Fig. 4685.—A. The existence, in most of the entire length of two parallel body cavities, a dorsal or neural, and a ventral or hæmal, separated by the bone, the vertebral axis.

B. The presence, in the ventral cavity, of the heart, a

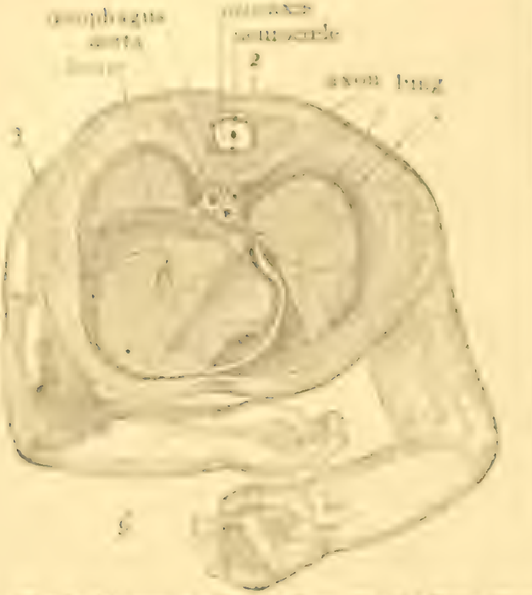


Fig. 4685.—Caudal Aspect of a Thoracic Transection of a Fetus about [illegible]

[illegible].—[illegible]

hollow muscular organ, rhythmically contractile during life.

C. The presence, in the ventral cavity, of a muscular tube, the enteron (alimentary canal).

D. The presence, in the dorsal cavity, of a subcylindrical rod, the neuraxis (cerebro-spinal axis), itself con-

Fig. 4686.—[illegible]

[illegible]

taining a cavity, the neurocoele (central canal and ventricles).

E. The greater distance of the neuraxis than of the enteron from the heart.

§ 9. Prop. III. Excepting at its first formation (when it is a groove with a dorsal furrow) the entire neuraxis is a tube, a subcylindrical mass inclosing a cavity. This cavity is the neurocoele, and the inclosing material constitutes the cœlian parietes. The existence of the neurocoele may be demonstrated by the transection of any part of

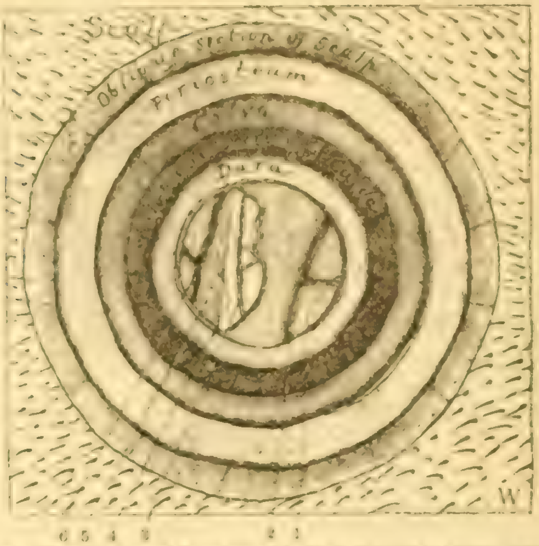


Fig. 4687.—The several Coverings of the Brain Exposed as a Series of [illegible]

[illegible].—[illegible]

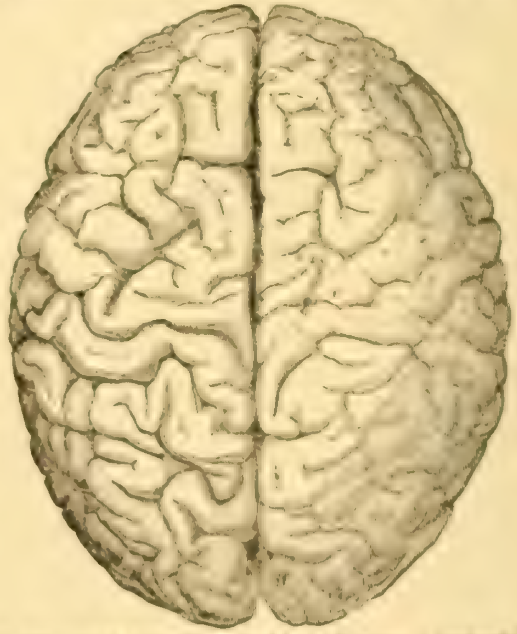


Fig. 4688.—Dorsal Aspect of the Brain of C. F. Gauss, a Distinguished Mathematician, who died at 78 years. (From R. Wagner, after Quain; [illegible])

the neuraxis in any other vertebrate, and in an immature human being; but with the adult, in certain regions, the olfactory bulbs (Fig. 4689) and most of the myel (spinal cord, Fig. 4684), the cavity is more or less completely obliterated.

§ 10. Prop. IV. *Location.*—The brain is contained mainly within the cranium, although part of the post-oblongata or even, as appears in Fig. 4684, a little of the cerebellum, may extend beyond the limits of the *Foramen magnum.* It is remarkably sheltered and clothed by the cranial bones and by the soft parts ectad and entad of them, Figs. 4686 and 4687.

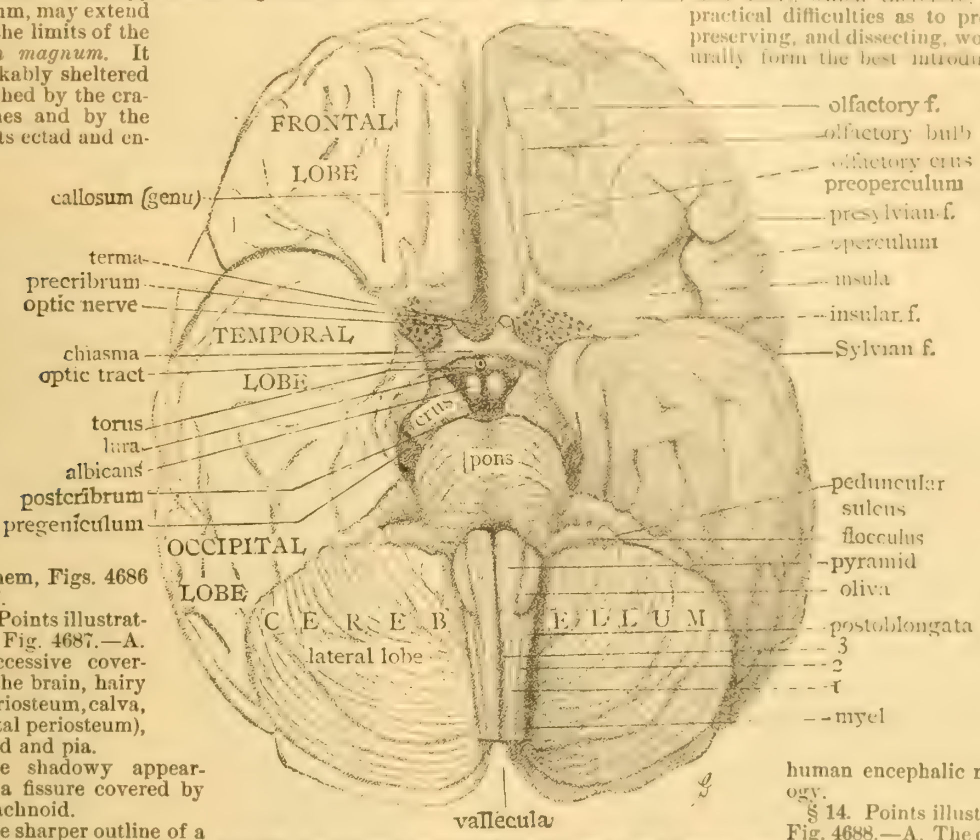


FIG. 4689. Base (Ventral Aspect) of the Brain. From Henle, Edinger, and nature; × .7. 1, Ventral ("anterior") column; 2, line between the ventral and lateral column; 3, ventrimesal fissure.

Preparation.—The cerebellum has been allowed to fall dorsad by its own weight; thereby the occipital lobes are divaricated somewhat, the encephalic curvature is reduced, and the crura are more fully exposed. The hypophysis and infundibulum have been severed from the torus, and the pia removed, together with the cranial nerve roots, excepting the optic. The right olfactory crus has been divided near its attachment. On the left the operculums are divaricated somewhat, so as to expose the ventro-lateral aspect of the insula.

Defects.—As may be seen from profile views of the brain (Figs. 4684 and 4711), in the natural condition of the organ the pons and the chiasma are nearly in contact, and the intervening region, crura, etc., is practically invisible; the ventral surface of the metepencephal also forms little more than a right angle with that of the prosodiencephal; consequently in a direct view of either region the other is greatly foreshortened, and even the equal division of the obliquity between them shows neither to advantage. The fresh or imperfectly preserved brain, when resting upon the dorsal aspect, will, however, straighten itself, as it is commonly represented. To include so large a surface within a figure of moderate size certain details must be inadequately presented or omitted altogether. For enlarged views and descriptions of special regions see the following figures: Postoblongata and pons, 4712 and 4720; crura and hypophysis, 4712 and 4728; cerebellum, 4717 and 4720; frontal lobe, 4752; entire hemicerebrum, 4770; cranial nerves, 4712. The fissures in the present figure, substantially as given by Henle, need not be regarded as signifying anything more than the general aspect of the cerebrum.

§ 11. Points illustrated upon Fig. 4687.—A. The successive coverings of the brain, hairy scalp, periosteum, calva, dura (ental periosteum), arachnoid and pia.

B. The shadowy appearance of a fissure covered by the piarachnoid.

C. The sharper outline of a fissure when the piarachnoid is removed.

D. The difficulty of separating the arachnoid from the pia; in a transection of a fissure, however, the former will be seen to pass across the fissure from gyre to gyre, while the latter, with blood-vessels, dips into the fissure as a fold.

E. The presence on the ental surface of the piarachnoid of a pial fold, the *ruga.*

F. The minutely punctate aspect of the depiated cortex by reason of the extraction of minute vessels entering from the pia. The ental surface of the pia, here represented smooth, should have a flocculent appearance, called *tomentum,* from the attachment of these vessels.

§ 12. Prop. V. The fundamental morphological idea of the brain is that it consists of a *series of segments,* comparable, although not, probably, strictly equivalent. The development (Vol. I., p. 636) and comparative anatomy of the organ can hardly be treated upon any other basis; it is recognized in the discussion of encephalic physiology and of psychology, and the descriptive anatomy of the organ is most conveniently based thereon.

§ 13. Prop. VI. The *segmental constitution* of the brain is invisible from the dorsal aspect (Fig. 4688), hardly suggested when the cerebellum as well as the cerebrum is in view; more obvious from the lateral aspect (Fig. 4715); still more so from the ventral side (Fig. 4689), clearer still from the mesal aspect (Figs. 4684, 4711, and 4718), and unmistakable with early embryos (Figs. 4690, 4693, and 4697), which therefore, but for practical difficulties as to procuring, preserving, and dissecting, would naturally form the best introduction to human encephalic morphology.

§ 14. Points illustrated by Fig. 4688.—A. The complete absence of any appearance of segmentation, all other regions being concealed from view by the preponderating cerebrum.

B. The division of the cerebrum into two approximately symmetrical halves, the hemicerebrums ("cerebral hemispheres") by a deep fissure, the intercerebral or "great longitudinal."

C. The general form of the cerebrum, and the extent of its fissuration in a highly educated man.

D. The lack of exact symmetry even with such principal fissures as the central (just cephalad of which on the right side is an *r*), and the occipital (deep indentations near the caudal end

§ 15. Points illustrated upon Fig 4689. A. The enormous preponderance of the visible parts of the prosencephal and epencephal over the other segments, thereby occasioning the not unnatural though very unphilosophical division of the entire brain into cerebrum (cerebrum proper, olfactory bulbs, and thalami) and cerebellum (with pons and postoblongata), the intervening narrow mesencephal being regarded as an isthmus merely.

From the morphological standpoint, however, the statement would be nearly reversed. The mesencephal is at one period the most prominent and distinct region; the cerebellum may be characterized as an hypertrophied bridge over the "fourth ventricle," and there are some grounds for regarding the olfactory bulbs as primary, and the cerebral hemispheres as their secondary appendages. See the writer's paper, "The Dipnoan Brain," *American Naturalist*, June, 1887.

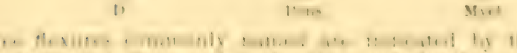
B. The expansion of the cerebrum beyond all other parts of the brain, the occipital lobes overlapping the cerebellum even when the latter is allowed to displace the former. For the relations of these parts to the anthropoid apes, see the writer's paper in the *American Association, Proceedings*, 1884, p. 424.

C. The absence of visible indication of the pyramid decussation; although this feature is commonly included, as in Fig. 4715, it is the exception rather than the rule in the writer's preparations, and is therefore omitted in this general view.

D. The overlap of the temporal lobe over the optic tract, as shown by the two interrupted curved lines on the right.

§ 16. Prop. VII. *The encephalic flexures.*—These are described in the article Development of the Brain (Vol. I., p. 668) as three, the cranial, the pons, and the neck. The second and third are temporary in man, respectively indicating the junction of the "myel" with the postoblongata and of the latter with the preoblongata. The cranial or mesencephalic flexure is a permanent feature of the human brain, as shown in Figs. 4684 and 4711. There is, in addition, a flexure, likewise permanent, at the diencephal, so that the prosencephal is dorsal instead of cephalad of it; this occurs in man and other Mammals and in Birds and Reptiles, but with Amphibia and "fishes" the prosocele and diacele are on approximately the same level; see the writer's paper, *American Association, Proceedings*, 1887, pp. 250, 251, and *American Naturalist*, October, 1887, pp. 914–917.

The relative positions of the several encephalic flexures although not their relative sharpness or the length of the intervening parts of the brain may be indicated to the eye approximately by a capital **W**, with an oblique line (half of a **V**) for the myel. In the accompanying diagram the three flexures commonly named are indicated by the words Cranial, Pons and Neck. Pr. stands for the prosencephalic region, and D for the diencephalic flexure.



§ 17. Points illustrated upon Fig. 4690.—A. The great relative bulk of the head, constituting about one-half of the entire body.

B. The indication of encephalic segmentation by slight furrows, represented by the converging lines upon the side of the head.

C. The prominence of the prosencephal at this period, forming the "top" of the head.

D. The sharpness of the cranial flexure, whereby two of the segments appear as a dorsal series, and two as a ventral, while the fifth appears partly in both series, as shown by Figs. 4690 and 4692.

E. The conditions of the eye and ear; the greater differentiation of the manus than of the pes; the presence of a short but distinct tail.

§ 18. Points illustrated upon Fig. 4691.—A. The continuation of the myelocele ("central canal") even to the root of the tail.

B. The sudden and great expansion to constitute the metacele ("fourth ventricle").

C. The marked constriction between the mesocele and the epicele.

D. The existence, on the contrary, of the greatest width of the metepicele opposite the ventral transverse furrow which is regarded by the writer as demarcating the cephalic portion (epicele) from the caudal (metacele).

E. The distinctness of that transverse depression of the floor. With some human embryos of this and later stages there is a marked flexion (the pons flexure) of this entire region, at about the middle of its length, so that the two segments are easily distinguished.

§ 19. Points illustrated upon Fig. 4692.—A. The greater width of the mesocele than of the diacele, so that the latter might be described as merely a passage between the former and the prosocele.

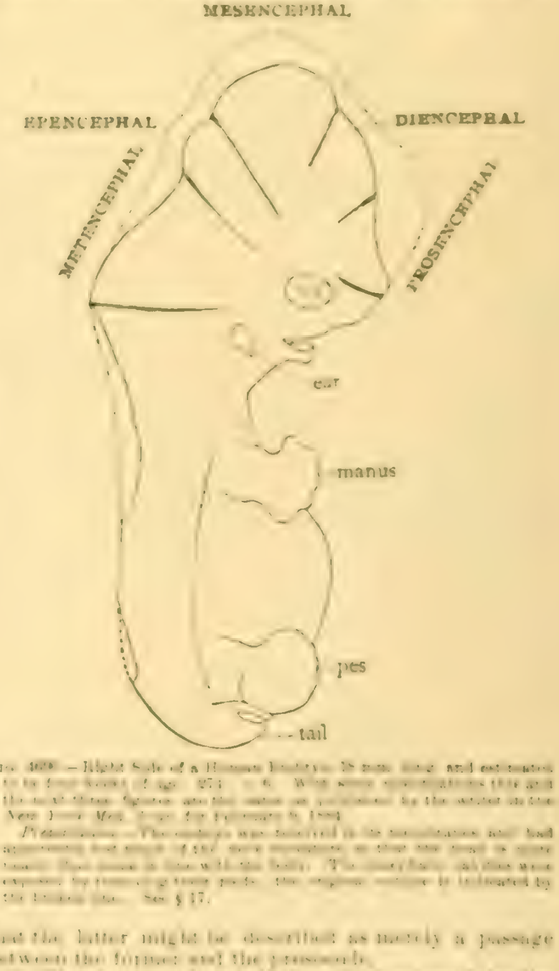


Fig. 4690.—Right Side of a Human Embryo 28 mm. long, and estimated to be four weeks of age. (27.) × 6. With some modifications this and the next three figures are the same as published by the writer in the New York Med. Jour. for February 9, 1884.

Preparation.—The embryo was hardened in [illegible] and had apparently lost [illegible] so that the head is more nearly than usual in line with the body. The encephalic cavities were exposed by removing these parts; the original outline is indicated by the broken line. See § 17.

B. The absence of any distinct thickening of the diacelian walls to indicate the formation of the thalami.

C. The mesal depression in the diacelian floor, probably representing the infundibulum.

D. The lateral extension of the paraceles, the cavities of the future hemicerebrums.

E. The presence of an elevation of the paracelian floor, probably representing the caudatum.

F. The continuity of the cavities at the junction of the prosencephal with the diencephal, and the absence of any indication of plexal intrusion at this period.

§ 20. Prop. VIII. *Normalization.*—This term is used to include all processes by which modified or morphologically abnormal forms and relations may be restored, either actually or ideally, to their known primitive and presumed normal conditions. *Rectification* would have nearly the same significance; it denotes the reduction of complex structures to simple, of irregular to regular, of crooked to straight, and of rough to plain. Examples of this process are the representation of the segments as subequal in size and on the same plane (Figs. 4693, 4695, and 4696); the lateral extension of the various outgrowths of the mesal parts (Figs. 4699, 4704, and 4705); the straightening of the medicornu (Fig. 4754); the schematic representation of the fissures (Figs. 4768 and 4769), and the designation of the human geniculums as pre and post rather than external and internal (§ 22, H).

§ 21. Prop. IX. The adult human brain presents great and perhaps peculiar departures from the general type as based upon embryology and comparative anatomy, and while anatomically admirable and physiologically nearly perfect, it may fairly be characterized as a morphological monstrosity. Among other general features, the segmentation of the brain is more easily recognized in many lower or more generalized vertebrates, and even in mammals where the cerebrum is less preponderant than in man; Figs. 4694 and 4698.

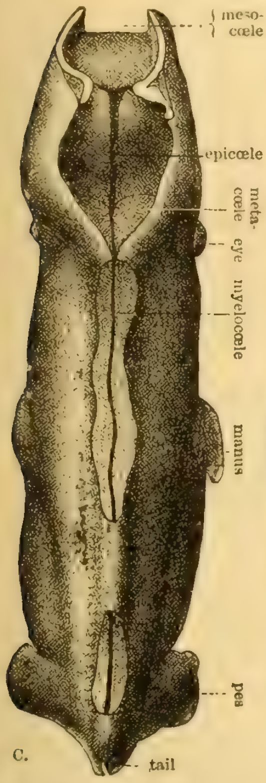


Fig. 4691.—Dorsal Aspect of the Embryo shown in Fig. 4690. 274; × 6. This and the three following figures are too deeply shaded. See § 18.

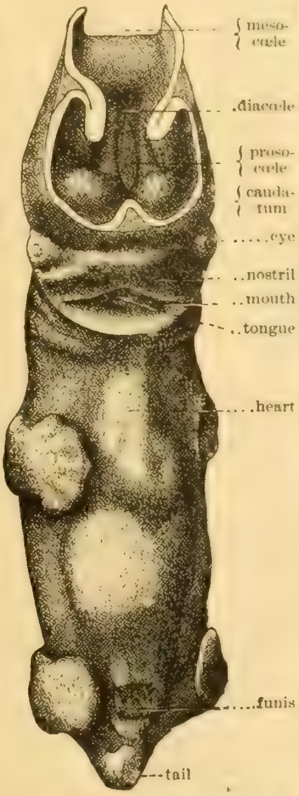


Fig. 4692.—Ventral Aspect of the Embryo shown in Figs. 4690, 4691, and 4693. 274; × 6. The left arm has been removed. See § 19.

§ 22. Points illustrated upon Fig. 4694.—A. The greater obviousness of the segmental constitution than with the adult human brain from any point of view.

B. The smaller relative size of the cerebrum than in man or the cat (Fig. 4698).

C. The much less extent of the callosum than in man or the cat, making it possible to uncover the diencephal without the medisection required in the cat (Fig. 4698).

D. The presence of a distinct roof of the diacœle, the interthalamic space, notwithstanding the cerebrum has been removed.

E. The relation of this roof, the diatela, to the habenas, the ridges demarcating the dorsal and ectocœlian from the mesal or entocœlian surfaces of the thalami.

F. The non-adhesion of the thalamus to the hemicerebrum in any way such as to indicate that the former enters into the composition of the paracœlian floor.

G. The less extension of the caudatum at the side of the thalamus, which so gravely modifies and complicates the segmental relations in man.

H. The less projection of the pregeniculum laterad of the postgeniculum, so that they present much more nearly than in man their proper relations of cephalic and caudal elevations of the diencephal.

I. The slightness of the transverse furrow between the pregeminum and postgeminum.

J. The more nearly equal size of the lateral and mesal (vermis) lobes of the cerebellum, and the concomitant absence of the vallecula, which is so obvious on the caudal aspect of the adult human cerebellum (Figs. 4689 and 4717).

§ 23. Prop. X. The recognition of the brain as a segmented organ is not dependent upon the determination of the exact number of segments, their equivalency, or their boundaries. It is quite probable, for example, that the postoblongata represents two or more *potential* segments or neuromeres, but practically it may be regarded as single.

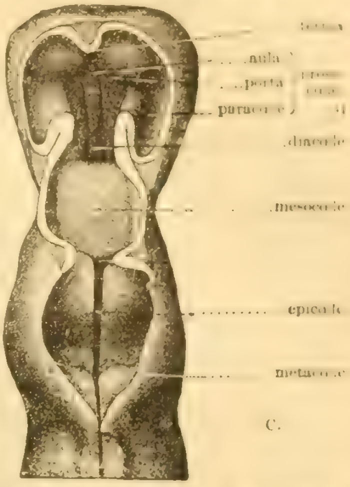


Fig. 4693.—The Entire Series of Encephalic Cavities of the Embryo shown in Figs. 4690–4692 Represented upon One Plane. This figure is a combination of parts of Figs. 4691 and 4692, as if the encephalic curvature were obliterated. This ideal straightening, a form of normalization (§ 20), may be illustrated as follows: Flex the index finger upon itself as far as possible; let the nail represent the prosocœle, the knuckle the metepicœle, and the prominent middle joint the mesocœle; from either the dorsal or palmar aspect only part of the convex surfaces are visible; but if the finger be extended all fall into one view. The object of this figure is to enable a comparison to be made between the encephalic cavities of this early embryo and those of the adult cat as shown in Fig. 4710. The differences are much greater in appearance than in reality, consisting mainly in the reduction of most of the cavities; the thickening of most of the parietes; the great and irregular extension of the lateral masses, hemicerebrums, containing the paracœles ("lateral ventricles").

§ 24. Prop. XI. Among living anatomists there is a very general, though not universal, admission of *five, definitive, encephalic segments*, represented respectively

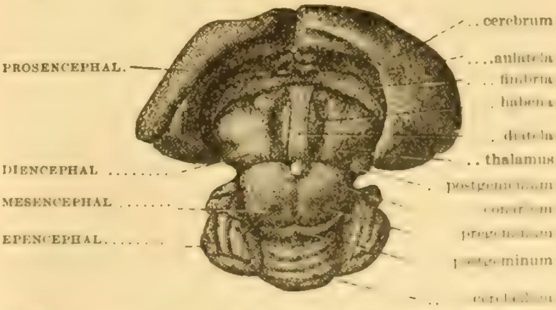


Fig. 4694. Dorsal Aspect of the Brain of a Young Rabbit, the Cerebrum and Cerebellum Pushed in Opposite Directions.

Preparation.—While fresh, the cerebellum was [illegible] caudad and the hemispheres cephalad, and the velum removed; the brain was then placed in strong alcohol so as to retain the [illegible] shape. The segmental names are at the left, the names of particular parts at the right. The specimen has been lost or destroyed.

[illegible]*

§ 25. Prop. XII. The chief differences of opinion respecting the number of these segments and their designations are indicated in the following Table:

Table of the Names of the Encephalic Segments, with their Principal Synonyms.

I. [illegible]	II. [illegible]	III. [illegible]	IV. [illegible]	V. [illegible]	VI. [illegible]	VII. [illegible]	VIII. [illegible]	IX. Fol (1884).	X. Rabl-Rückhard (1884).	XI. Haeckel [illegible]
Prosencephal	[illegible]	[illegible]	Forebrain	[illegible]	Prosen.	Prosen.	Prosen. (in part)	Prosen.	[illegible]	Proto-psyche
Diencephal	[illegible]	Thalamencephalon	[illegible]	[illegible]	Mesen. (in part)	[illegible]	Prosen. (in part)	[illegible]	[illegible]	Deuto-psyche
Mesencephal	[illegible]	[illegible]	Midbrain	[illegible]	Mesen. (in part)	Mesen.	Mesen.	Mesen.	Mesen.	Meso-psyche
Epencephal	[illegible]	[illegible]	Hindbrain	[illegible]	[illegible] (in part)	[illegible]	[illegible] (in part)	Epen.	[illegible]	Meta-psyche
Metencephal	[illegible]	[illegible]	Afterbrain	[illegible]	[illegible] (in part)	[illegible]	[illegible] (in part)	[illegible]	[illegible]	Epi-psyche

§ 26. *Commentary on the tabular arrangement of the names of the encephalic segments.*—The order of the columns is not chronological, and is determined by various considerations. In VI.–X. the components of encephalon, where they occur, are abridged by the dropping of the last three syllables.

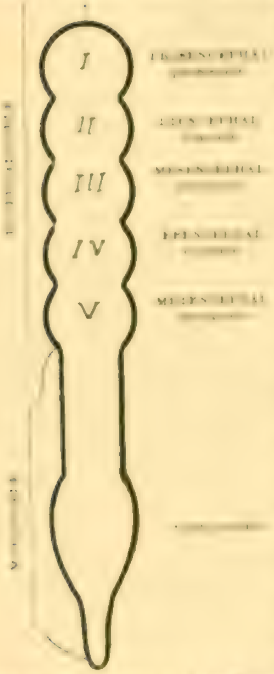


Fig. 4695.—[illegible]

With unimportant differences this table was published in the *New York Medical Journal*, March 28, 1885, and in "Anatomical Technology," 1886.

I. No originality is claimed for these terms. Aside from their terminations (which are English instead of Latin, after the analogy of many terms, *e.g.*) they are identical with those of Quain, excepting that *diencephalon* is preferred to *thalamencephalon*, both because it is shorter and because the prefix is readily compounded with words giving *diacœle*, *diaplexus*, *diatela*, *diaterma*, etc. *Diencephalon* is given (Quain, ii., 828) as a synonym of *thalamencephalon*, and it is adopted in the recent paper of H. F. Osborn (*Journal of Morphology*, II, No. 1).

VI. Owen seems to be alone in regarding the mesencephal as including the thalami (I., 277 [illegible] 97, 102).

IX. Fol's [illegible] and [illegible] present no advantages over the terms here employed.

X. Rabl-Rückhard does not actually use the term [illegible], but it seems to be the logical alternative of his [illegible].

XI. Aside from the unsuitable substitution of a metaphysical term for the anatomical ones, Haeckel has caused needless confusion by transposing the commonly accepted Greek equivalents for *Vorder* and *Nach*.

§ 27. Commentary on Fig. 4695.—A. The myel is made to be longer than the brain; the expansion near its caudal end is well marked in birds and some other vertebrates.

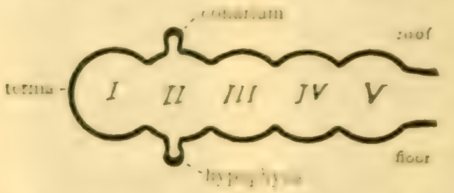


Fig. 4696.—Diagram of the [illegible] Brain, as it were the Mesal [illegible] of the Right Half of Fig. 4695. [illegible] See § 14.

B. The five divisions of the encephalocœle are made of equal size, not because they actually are so at any particular period of development, but because, as the writer understands it, each vesicle is at some period as large as any other vesicle has been at some (not usually the same) period.

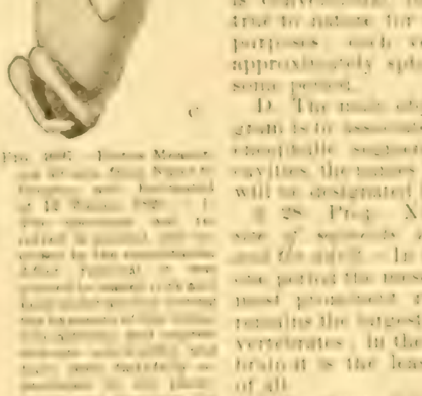


Fig. 4697.—[illegible]

C. The form adopted is conventional, but sufficiently true to nature for diagrammatic purposes; each vesicle has an approximately spherical form at some period.

D. The main object of the diagram is to associate with the five encephalic segments and their cavities the names by which they will be designated in this article.

§ 28. Prop. XIII. *Relative size of segments in the embryo and the adult.*—In the embryo at one period the mesencephal is the most prominent region, and it remains the largest in some lower vertebrates; in the adult human brain it is the least conspicuous of all.

§ 29. Prop. XIV. *Segmental inequality.*—Although originally subequal in size, certain segments early manifest a tendency to extend beyond their neighbors in one or more directions. In man and the mammals generally this overlapping is in inverse ratio to the original size of the parts. The mesencephal, at one period most prominent, is encroached upon by the diencephal at the sides, by the pons ventrad, the cerebellum dorsad, and all are eventually covered by the cerebrum, primarily a comparatively insignificant portion of the brain.

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* [illegible]

§ 30. Points illustrated upon Fig. 4697.—A. The general form of the body and limbs at this period.

B. The visibility of all the encephalic segments, excepting the diencephal; even this may be regarded as represented by the optic nerve, dimly seen through the indentation at the ventral margin of the cerebrum.

C. The marked preponderance of the cerebrum.

D. The absence of any lateral fissures excepting the Sylvian fossa; compare, however, the right hemicerebrum, as shown in Fig. 4756.

E. The simplicity of the other regions, better shown in Fig. 4756; the cerebellum is a narrow and undivided mass, as in Fig. 4714; the mesencephal presents a slight transverse depression between the pregeminum and postgeminum.

§ 31. Prop. XV. This segmental overlapping is, upon the whole, greater caudad than cephalad, most of the segments presenting something like the "rake" of the mast of a ship. The cerebellum, for example, not only extends both cephalad and caudad from its connections with the epencephalic floor, but is tilted distinctly caudad (Figs. 4684, 4711, 4719, and 4721).

§ 32. Points illustrated upon Fig. 4698.—A. The possibility, even with so high a mammal as the cat, of making a preparation that, without disturbing the essential, morphological features of the organ, may exhibit all of the encephalic segments, in part at least, excepting the last, the metencephal.

B. The tendency of three of the encephalic segments to overlap those caudad of them. The cerebellum, the epencephalic roof, partly conceals the postoblongata, metencephal, in its natural attitude; in the present figure it is tilted caudad. The mesencephal (geminal or optic lobes) is covered partly by the cerebellum and partly by the cerebrum, and also at the sides overlapped somewhat by the postgeniculums, elements of the diencephal; in the figure these bodies are in deep shadow, crossed by the line 3 on the right, and on the left by the line leading to the postgeminum. Finally, the cerebrum conceals the diencephal and mesencephal, and even the cephalic slope of the cerebellum in the cat, while in man it alone is visible when the brain is viewed from the dorsal aspect.

C. The relations of the callosum and fornicommissure to the two hemicerebrums, as lines of secondary adhesion between the two, the one dorsal and the other ventral.

D. That the triangular area, hemiseptum, is really only a portion of the mesal wall of either hemicerebrum, which has been intercepted between the two lines of junction above named.

E. That the interval, pseudocœle ("fifth ventricle") between the two hemiseptums, has no connection with the true encephalic cavities.

F. That the callosum and fornix are in no sense parts of the roof of the diacœle (third ventricle): this is constituted by (1) its proper endyma, (2) the pia covering this, as all other parts of the brain, (3) the pia pertaining to the fornix, which, with the layer (2) and the intervening vessels, constitutes the velum.

G. Incidentally it may be remarked that the cruciate fissure in cats and dogs constitutes, as it were, a gash across the mesal margin near the cephalic end of the hemicerebrum; it appears, therefore, upon both the mesal and the dorso-lateral aspects; the well-known and easily-experimented upon motor areas of the limbs occupy the U-shaped gyre between the cruciate and coronal fissures. It does not follow, however, that the cruciate fissure and the human central fissure are homologous.

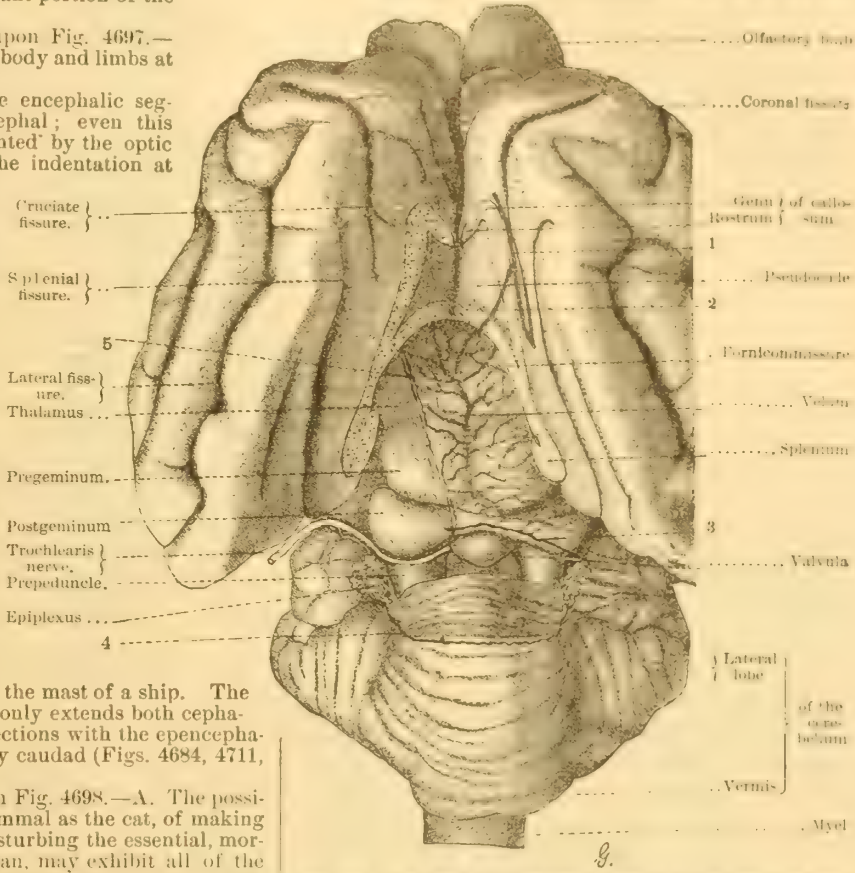

FIG. 4698.—The Brain of a Cat from the Dorsal Aspect, after the Callosum and Fornix had been Divided and the Hemicerebrums Divaricated. 4/4 : 2. 1, Artery (precerebral ?); 2, artery joining 1, perforating the callosum from the velum; 3, 4, lines of division of the arachnoid, between the cerebrum and cerebellum; 5, line of division of the velum, which is partly removed on the left side so as to expose the thalamus and gemina of that side. See § 32.

Preparation.—While fresh and supported by the *basis cranii*, the hemicerebrums were carefully separated so as to expose the callosum; this was divided, beginning with the splenium, then the fornicommissure until the incision reached the point of attachment of the velum. The cerebellum was tilted caudad and the arachnoid between it and the postgeminum divided; the cerebellar edge of the arachnoid is represented by the line 5. The cephalic part of the valvula is shown as if inflated with air. On the left side, along a line (5) extending obliquely caudo-mesad from under the margin of the fornicommissure, the two layers of pia constituting the velum were divided, and the part at the left removed so as to expose more distinctly the postgeminum, pregeminum, and thalamus. The cerebral pia was removed.

Defects.—The arteries should have been injected with a red mass, for the better exposition of the pia, the plexuses, and especially the mesal artery (2) which penetrates the callosum. No attempt has been made to show the lines of reflection of the arachnoid between the two hemicerebrums, along a line corresponding with the ventral margin of the falx and indicated approximately in the [illegible]. The fornicommissure is represented too thick at a [illegible]. The trochlearis nerve (N. iv.) stops too sharply at the margin of the valvula, from which it arises. The convexity of the [illegible] is too sharply defined. A similar preparation of the human brain would be desirable, but extremely difficult to make, on account of the weight of the hemicerebrums.

§ 33. Prop. XVI. The relations of the prosencephal in the diencephal are further complicated by the intimate fusion of the crura of the latter (thalami) with the fibers of the former (consulstriata). Although, therefore, in the early embryonic stages (Fig. 4692), it is very easy to distinguish between the two segments, there is some difficulty in the adult. For convenience, in the present article, the capsula ("internal capsule") is adopted provisionally as the boundary so far as regards the thalamus and the lenticula (part of the striatum); but the same [illegible] relation [illegible] between the [illegible] and the caudatum, [illegible] prosencephalic parts, and the whole subject requires further elucidation.

§ 34. Prop. XVII. Transections at any level crosswise of the brain usually affect two or more segments. This is illustrated in the following diagrams (Fig. 4699).

FIG. 4699.—Diagrams Illustrating the Lateral Overlapping of the Mesencephal [illegible]

§ 35. Prop. XVIII. Potential triplicity of the encephalic segments.—Although primarily mesal and simple, each segment excepting the last* (metencephal) presents at some period and in some vertebrates a distinctly threefold condition with one mesal and two lateral portions. The prosencephalic triplicity is exhibited in all air-breathing vertebrates and some aquatic forms (Dipnoans, etc.); with birds and frogs the mesencephal is markedly tripartite (Fig. 4700); with man and other mammals, and likewise with some other vertebrates, the epicoele presents more or less extensive "lateral recesses" parepicoelia (Figs. 4702, 4704, and 4720); finally, with most vertebrates whose development has been studied the embryonic diencephal protrudes at either side as optic vesicle that becomes the retina and optic nerve (Figs. 4704 and 4703).

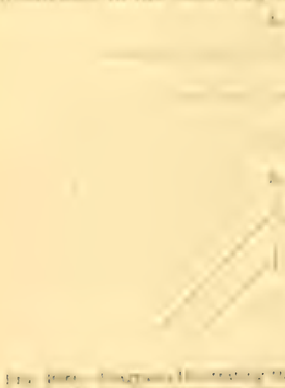

FIG. 4700.—Brain of Frog [illegible]

§ 36. Points illustrated upon Fig. 4702.—A. The effect of the cranial flexure, the two segments, prosencephal and [illegible], with their cavities, appearing upon the same section surface.

B. The triplicity of the epicoele, consisting as it does of a mesal portion and two lateral extensions, the lateral recesses (parepicoelia).

C. The embryonic continuity of the endyma and more substantial elements of the parietes around the lateral recesses which are almost invariably torn open in the removal or manipulation of the brain (see Fig. 4720).

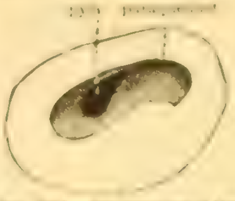

FIG. 4701.—[illegible]

D. The corrugation of the thin portion of the parepicoelian parietes preparatory to the formation of the epiplexus.

§ 37. Points illustrated upon Fig. 4703.—A. The continuity, general form, and relative size of the several divisions of the adult human encephalocoele, as viewed obliquely from the ventro-dextral aspect.

B. The obvious triplicity of the prosocoele and the existence of lateral extensions of the epicoele.

C. The slenderness of the mesocoele as compared with its relative size in the embryo (Fig. 4690) and in the adults of some other vertebrates (Fig. 4701).

D. The general modifications of the primitive and typical condition of the encephalic cavity which led the older anatomists, and still lead some of their modern successors, to regard the whole as comprising four "ventricles," a first and second (lateral), a "third," and a "fourth," the aula being ignored and the mesocoele considered merely as a "passage from the third ventricle to the fourth."

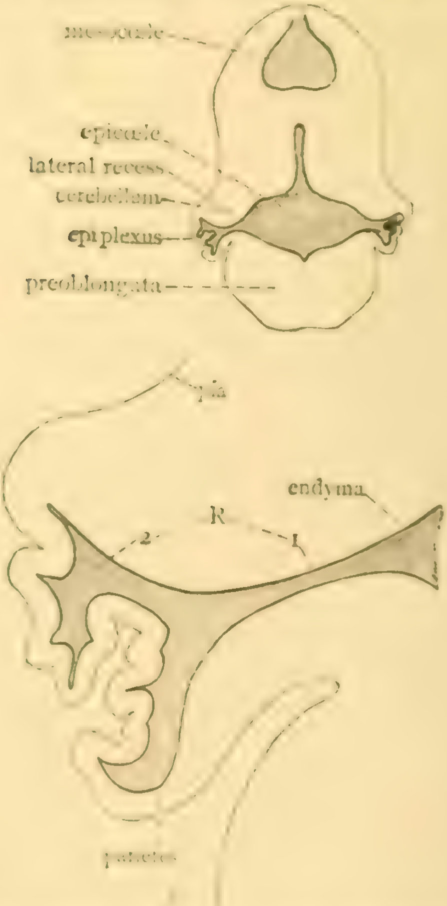

FIG. 4702.—Transection of the Head of an Embryo Rabbit, Sixteen Days [illegible]. Upper figure × [illegible]; lower, × [illegible], enlargement of part of the upper.

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* [illegible]

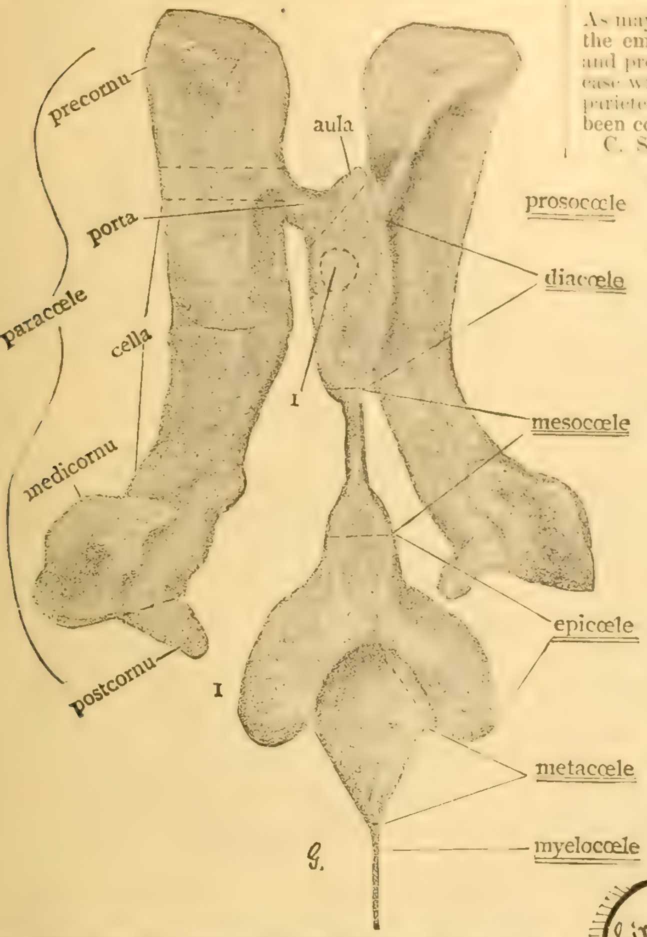

FIG. 4703.—Cast of the Encephalic Cavities, Ventral Aspect : approximately correct. · 1 (?). From Weisker, modified. The names at the right, doubly underlined, designate the five divisions of the encephalocœle, together with the slender myelocœle (central canal of the spinal cord). The metacœle and epicœle together constitute the "fourth ventricle" of the text-books; the mesocœle corresponds to the aqueduct or iter ; the diacœle equals the "third ventricle" less the aula, which is the mesal part of the prosocœle ; prosocœle includes all not already specified, viz., the mesal aula, the lateral paracœles ("lateral ventricles") and the two portas through which they are continuous. The names at the left designate the parts of the paracœle, viz., the cella, extending caudad from the porta ; the precornu, extending cephalad ; the medicornu, extending in a spiral direction laterad, ventrad, cephalad, and mesad, successively ; and the postcornu projecting caudad from the cella. I is placed near the top of the right lateral recess of the epicœle. The larger part of the figure is modified from a photograph of the wax model made by Weisker, of Freiburg ; the metacœle, myelocœle, and part of the epicœle are from a cast of the cavities in a child. The ventral aspect was chosen in order to display to better advantage the uninterrupted series of mesal cavities, and the portas.

Defects.—The writer doubts whether any part represents the corresponding cavity accurately. The portas are too long ; compare Fig. 4741. The diacœle presents neither the orifice for the medicommissure (the presumed location of which is indicated by the dotted circle (2) just caudad of the portas) nor the marked ventral extension toward the hypophysis. The medicornua are not sufficiently curved ; in reality the extremity of each approaches the diacœle within about 2.5 ctm.; the postcornua are too short ; the boundaries of the epicœle are vaguely and perhaps incorrectly indicated.

§ 38. Prop. XIX. Commentary on Fig. 4704.—A. As stated above, this diagram must be regarded as the expression of the writer's present morphological ideas respecting the brain as a series of mesal segments, with or without lateral extensions. These ideas may or may not be sound, but the facts upon which they are based belong to the common stock of knowledge, and need be but briefly stated here.

B. In all mammals where they have been looked for, and in some other vertebrates (probably in most) there extends latero-ventrad from the "fourth ventricle" a recess which is commonly described as open at the end. As may be seen from Fig. 4702, it is certainly closed in the embryo ; it is closed in an alinjected shark's brain, and probably the common idea respecting it is due to the ease with which, in the adult mammal, its membranous parietes are torn in the removal of the brain. They have been compared by Burdach to the "lateral ventricles."

C. Some adult human brains present a slight groove at each side of the aqueduct, the contracted mesocœle ; with frogs, some Reptiles, and all Birds, the mesencephalic cavity is distinctly tripartite, with distinct and considerable cavities (paraqueducts) in the lateral lobes (Fig. 4700).

§ 39. Points illustrated by Fig. 4706.—A. The communication of the paracœle (lateral ventricle) with the mesal series of encephalic cavities solely through the porta ("Foramen of Monro").

B. The reduction in size of the aula, the mesal division of the prosocœle, relatively to the diacœle, and to the prosocœlian lateral extensions, the paracœles.

C. The location, in man and other mammals, of the aula at the dorso-cephalic side of the diacœle, instead of directly cephalad as in Amphibia ; see § 16.

D. The concomitant change in the direction of the diacœlian and prosocœlian floors ; instead of cephalo-caudal, their direction is more or less nearly dorso-ventral.

E. The crowding of the conarium caudad by the overlying cerebrum ; the conarium and hypophysis are retained in the figure, however, mainly as landmarks.

F. The relation of the rima (essential part of the "great transverse fissure") to the porta. The line along the meso-ventral aspect of the hemicerebrum represents a narrow tract where the paracœlian parietes are reduced to the lining endyma and the covering pia, and where the latter,

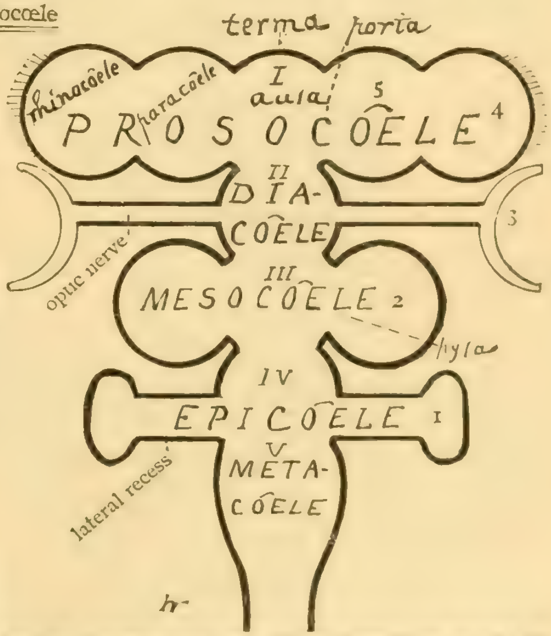

FIG. 4704.—Diagram Exhibiting the Writer's Present Ideas respecting the Relations of the Lateral Extensions of the Encephalocœle. The Roman numerals, as in Fig. 4695, designate the five encephalic vesicles, and *not the "ventricles."* 1, "Lateral recess" parepicœle; 2, "optic ventricle" (paraqueduct), optocœle of "Anatomical Technology"; 3, the optic nerve and retina, formed originally (see Vol. I., Fig. 509) as the "optic vesicle," an outgrowth of the diencephalic vesicle prior to the formation of the "cerebral vesicle"; 4, the rhinocœle or cavity of the olfactory bulb; 5, the paracœle or "lateral ventricle" proper, the cavity of either hemicerebrum, communicating through the porta ("Foramen of Monro") with the aula or mesal division of the prosocœle, and thus only through it with the caudal portions of the encephalocœle.

or its vessels) intrudes into the paracœle, still covered, however, by the endyma. The rima always begins at the margin of the porta, and extends in man to near the tip of the medicornu; see § 113 and Figs. 4748 and 4757.

(f) The secondary and morphologically unessential nature of the [illegible] thalami, the enormous thickening of the thalamus, the lateral wall of the diacœle and of the [illegible], the floor and [illegible] of the paracœle. This feature of the mammalian brain, which is very confusing and not altogether easy to describe, may be learned by a diagram like the above, where the parietes are represented of nearly uniform thickness, as in the embryo and in adult [illegible].

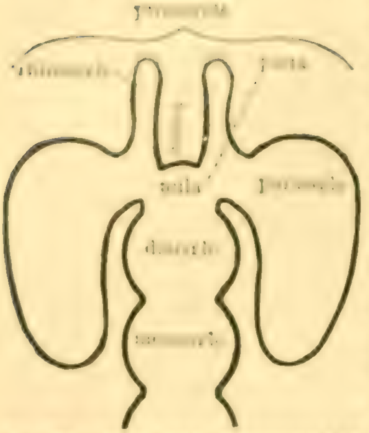

FIG. 4705.—Diagram of the Prosocœle and [illegible] Adjoining Cavities, from the Dorsal (or Ventral) Aspect.

§ 40. Prop. XX. The cavity commonly called "third ventricle" really represents the mesal portions of the cavities of two segments. The larger is the interval between the thalami, surrounding the medicommissure and extending ventrad to the tuber; this is the diacœle. The smaller is the mesal portion of the prosocœle, and connects at either side through the porta with the lateral division of the prosocœle, the paracœle; this mesal part, bounded laterally by the portas, cephalad by the fornicolumns and præcommissure, and limited caudad by the cephalic margins of the thalami and ventrad by the ventral ends of the portas, has been called aula by the writer since 1878 for the sake of indicating his estimate of its morphological significance; in some lower vertebrates it is much larger than in man.

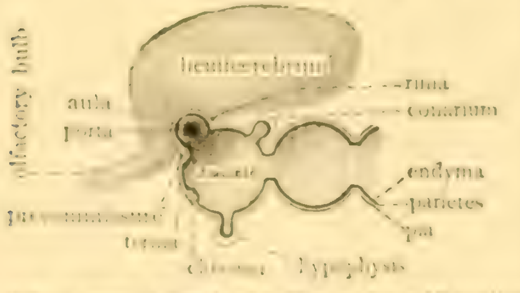

FIG. 4706.—Diagrammatic Vertical Section of the Prosencephal and Thalamencephal [illegible] the Hemicerebrum; corresponding to the right half of Fig. 4705, seen from the mesal aspect. (See § 40.)

§ 41. Prop. XXI. The porta ("Foramen of Monro") is an orifice at either side of the aula connecting it with the paracœle ("lateral ventricle"). It is a constant and essential feature of every brain since the distinctly tripartite condition of the prosencephal segment. It has only a secondary relation with the rima and should not be confounded with it. The porta is completely circumscribed, its dorsal limit being as definite and its dorsal wall as [illegible], though less substantial than the ventral (see Figs. 4741, 4742, and 4744).

§ 42. Prop. XXII. The rima (part of the "great transverse fissure") is secondary in development and not constant even where there is a distinct [illegible]. It is a line along the side of the [illegible], beginning at the dorsal end of the porta, where the proper parietes are thinned or wholly obliterated for the intrusion of a pial prolongation (paraplexus). But (1) this plexus fills the space, and (2) the endyma is carried before it, so that there is no true solution of continuity. The only way in which the porta and the rima can become continuous is by the artificial rupture of the membranous attachments.

§ 43. Prop. XXIII. The simplest expression of an encephalic segment is by a short tube comprising (1) a cavity (cœle or "ventricle"); surrounded by its parietes, a [illegible] mass covered by a vascular membrane (pia) and lined by a ciliated epithelium (endyma).

§ 44. Prop. XXIV. In what may be regarded as an approximately typical condition, the parietes consist of three layers or strata, viz., an ental, mainly cellular, adjoining the endyma, the entocinerea ("central tubular gray"); an ectal, mainly cellular, adjoining the pia, the ectocinerea (cortex); and intermediate, fibrous, between the other two, the alba or medulla (see Fig. 4707).

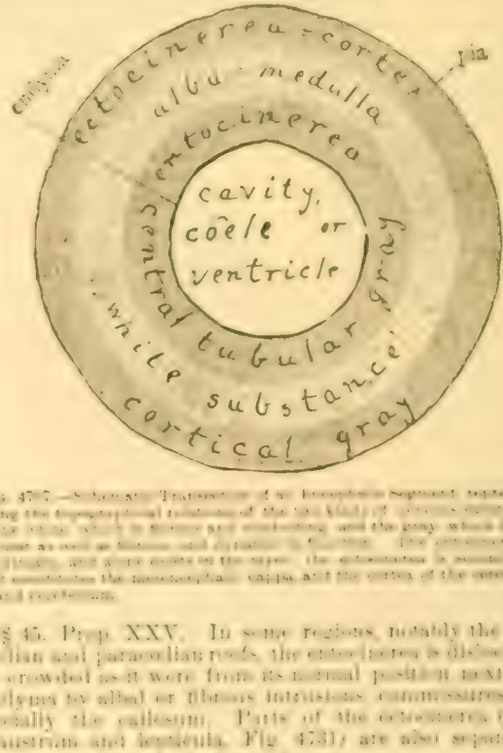

FIG. 4707.—Schematic Transection of an Encephalic Segment, representing the hypothetical relations of the [illegible] kinds of nervous substance, the white, which is fibrous and conducting, and the gray, which is [illegible] as well as fibrous and [illegible] in function. The entocinerea is primary, and [illegible]; the ectocinerea is secondary, [illegible] and the cortex of the cerebrum and [illegible].

§ 45. Prop. XXV. In some regions, notably the epicœlian and paracœlian roofs, the entocinerea is dislocated or crowded as it were from its normal position next the endyma by allied or fibrous intrusions, commissures, especially the callosum. Parts of the ectocinerea (e.g., claustrum and lenticula, Fig. 4731) are also separated more or less completely from the rest.

§ 46. Prop. XXVI. Unequal thickness of the parietes.—In the earliest stages the cœlian parietes are of approximately equal thickness throughout, although it may be, as held by Spitzka, that the roof is never so thick as the floor. With some low or generalized vertebrates—e.g., *Squatina*, a shark (Parker, *Nature*, December 30, 1886); *Menopoma*, a salamander (the writer, *New York Medical Journal*, February 9, 1884, Fig. 16); *Ceratodus*, a Dipnoan (the writer, *American Naturalist*, June, 1887)—this condition prevails throughout life, at least with certain regions; with man, until the fœtus attains a length of at least 6 ctm. and an estimated age of 12 weeks (see Fig. 4708), the hemicerebral parietes are almost uniformly thin; when 24 ctm. long and about 20 weeks old, certain regions are considerably thicker than others, as seen in Fig. 4709; in the adult brain of man, and indeed of mammals generally (Figs. 4710 and 4746), the difference between even closely adjacent portions of the parietes is simply enormous; compare, e.g., the mesencephalic floor (crura) with the caudal part of its roof, valvula (Figs. 4684 and 4711); the two divisions of the epicœlian roof, cerebellum and lingula (Figs. 4684, 4711, and 4719); the diacœlian sides, thalami, with the floor, tuber or terma (Figs. 4684 or 4711); the thin or membranous parts (lamina, terma, pala, etc.) adjoining the rima with the adjoining hippocamp and caudatum (Figs. 4709 and 4751); or the translucent hemiseptum with the mass just cephalad of the precornu (Figs. 4710 and 4746).

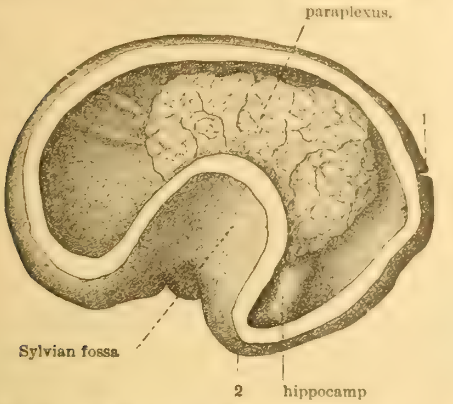

FIG. 4708.—The Hemicerebrum of a Fœtus (Measuring 6 ctm. from Bregma to Heel and Estimated at 12 Weeks) Opened from the Lateral Aspect. 340; × 3. This preparation (really the right hemicerebrum, but reversed in drawing) is figured in the *New York Medical Journal* for February 16, 1884, but unreversed and of half the present size; the length of the fœtus is there given incorrectly as 4 ctm. 1, A fissure, occipital, calcarine or lambdoidal; 2, tip of temporal lobe.

§ 47. Points illustrated by Fig. 4708.—A. The large size of the paracœle and the thinness of the parietes.

B. The nearly uniform thickness of the parietes so far as exposed.

C. The extent of the paraplexus, and its fulness as compared with that in the adult; possibly when fresh it entirely filled the paracœle, but was contracted by the alcohol.

D. The similarity of the precornu and medicornu.

E. The absence of distinct indication of the postcornu, indicating that this may be formed eventually not by a special protrusion caudad but by the thickening of the parietes in such a way as to leave an occipital space of variable size.

F. The commencing formation of the hippocamp as a corrugation of the mesal wall of the medicornu.

G. The non-extension of the paraplexus and thus of the rima to the extremity of the medicornu.

H. The presence of at least one distinct fissure (1), the calcarine, occipital, or lambdoidal.

I. The evidences of some mesal fissures, perhaps transitory, as slight corrugations just cephalad of the plexus.

J. The formation of the Sylvian fossa, with as yet no trace of the insula.

§ 48. Points illustrated by Fig. 4709.—A. The great extent of the paracœles at this period, relatively to the entire cerebrum, and to the mesal part of the prosocœle, the aula.

B. The less difference in the thickness of the parietes than in the adult.

C. The distinct collocation of the hippocamp with the hippocampal fissure.

D. The topographical relation of the Sylvian fossa, the first stage of the Sylvian fissure, to the caudatum.

E. The extension of the postcornu farther caudad of the aula than the precornu extends cephalad.

F. The absence of the insula at this period.

G. The outgrowing margin of the operculum.

H. The depth and peculiar shape of the lambdoidal fissure; See Fig. 4758.

§ 49. Prop. XXVII. *The brain as a house.*—Within certain limits the brain may be likened to an edifice, and the comparison has been carried out in some detail by the writer in "Anatomical Technology" (p. 413). with Schwalbe and others he believes that architectural terms, *floor*, *roof*, *sides*, may be employed appropriately in indicating the general locations of the segmental parts relatively to each other and to the common cavity, and he has proposed two specific terms, *aula* (a hall), and *porta* (a doorway), for the designation of certain portions of the cavity.

§ 50. Prop. XXVIII. *Irregularities of contour.*—In the brain straight lines and plane surfaces are infrequent, and the spiral form is not uncommon; hence dissections are often more instructive than mechanical sections, and normalization, actual or ideal (§ 20), is sometimes desirable.

§ 51. Prop. XXIX. *Commissures, etc.*—Of the parts connecting lateral masses across the meson, whether cellular or fibrous, whether direct (true commissures) or oblique (decussations), some are merely specializations of pre-existing floors or roofs; *e.g.*, precommissure, postcommissure, supracommissure, pons; others, the callosum and fornicommissure, are either new formations or marked extensions of pre-existing lines or areas of conjunction (Fig. 4757); the medicommissure, finally, as well remarked by Spitzka, is rather a fusion of contiguous surfaces than a commissure in the usual sense of the word.

§ 52. Prop. XXX. *Atrophic parts.*—Certain parts, (terma, hemiseptum, valvula, torus) which are very thin and apparently functionless, nevertheless serve to contain the cœliolymph (cerebro-spinal liquid), and may have a morphological significance as representing parts more

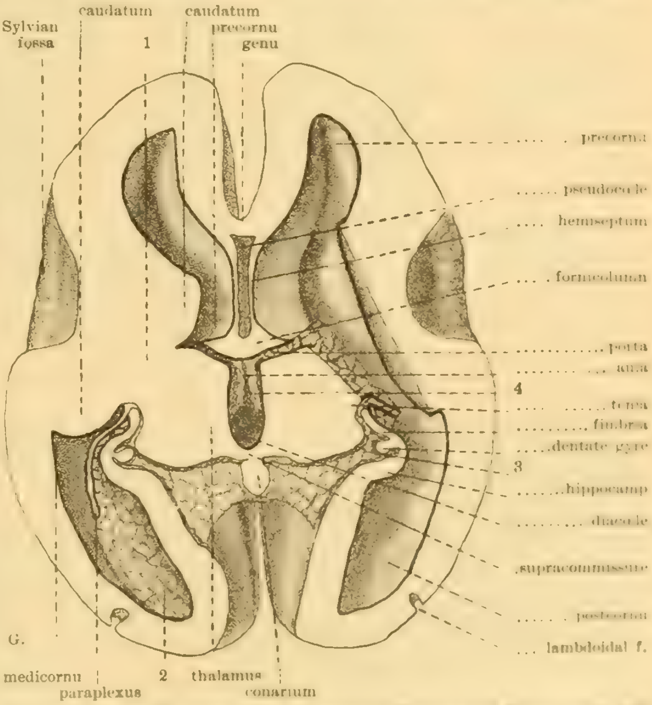

FIG. 4709.—Ventral Exposure of the Prosocœle of a Fœtus about 24 ctm. Long, and Estimated to be 20 Weeks Old. 499; × 1.5. 1, Line of junction between the thalamus and the caudatum; 2, thin extension of the paraplexus into the postcornu; soon after the preparation was made this became detached and was lost; another specimen must be depended upon to show whether or not such extension exists, and in what way it is disposed of in case it be deciduous; 3, hippocampal fissure; 4, diaplexus.

Preparation. The brain was hardened in place by arterial injection; the scalp and calva were removed piecemeal, and the dorsal part of the cerebrum removed by one sweep of the knife under alcohol. The [illegible] at each side as indicated by the heavy line [illegible]. The left caudatum was removed so as to expose the paracœle more completely on that side and make the figure comparable with that of the cat [illegible].

developed in other forms. Two other parts, the conarium (pineal body) and the hypophysis (pituitary body) [illegible], but are not known to have definite functions. Their peculiarities will be considered in connection with the diencephal (§ 114), of which they are appendages.

§ 54. Prop. XXXI. *Riparian parts.*—Along the ripas, or lines of reflection of the endyma upon itself or plexus, the contiguous nervous portions are commonly reduced in thickness, so as to resemble the terma, valvula, and velum in some degree. Such are the ligula and obex at the caudal end of the metacœle; the fimbria along the hippocampal margin of the rima, the tænia along its caudal margin, and the pedicle at its extremity (Figs. 4751, 4756, and 4757); a similar part may probably be recognized with careful inspection along the line of reflection of the endyma from the velum and adjacent lobes of the cerebellum (Figs. 4711, 4717, and 4719).

§ 55. Prop. XXXII. The riparian condition may not be incompatible with distinct and even important functions. The supracommissure (Fig. 4730) and the fornix (Fig. 4726), for example, may be in one sense parts of transition from nonnervous to nervous portions, but they probably, like the fimbria, have some distinct use.

§ 55. Prop. XXXIII. *Marginal tissues.*—The riparian parts mentioned under Prop. XXXI. consist of alba; but with the cerebrum and cerebellum the cortical margins have a special morphological interest, and are but little known. In the depths of the callosal fissure, for example, the cinerea has a rostral margin (Fig. 4736); this is probably continuous caudad over the splenium (Fig. 4764) with the dentate gyre (*fascia dentata* and *fasciola cinerea*) and cephalad over the genu with the prelaminal cortex. Even less known are the ental margins of the cerebellum; the lingula comprises one portion, and of course there is a continuity of cortical edge on either side over the peduncles to the medulla.

§ 56. Prop. XXXIV. Physiologically the intermediate portions of organs are commonly most important, as well as most easily recognized and examined; but morphologically the extremes have great significance, and present as yet unsolved problems for future investigation.

§ 57. Points illustrated by Fig. 4710.—A. An arrangement and circumscription of the encephalic cavities in the adult cat not essentially (naturally) essentially identical with that in the human adult (Fig. 4746) and fœtus (Fig. 4709) and in vertebrates generally.

B. The great differences in size and shape between the various divisions of the encephalocœle; the præcœle is little larger than the myelocœle and is tubular; the mesocœle is narrow but high; the metacœle wide but shallow; the diacœle is very irregular; the myelocœle is patent throughout, while in man it is nearly obliterated. The [illegible] lateral recesses are not exposed, so the triple constitution of a typical segmental cavity is exhibited only by the prosocœle with its mesal aula and lateral paracœles.

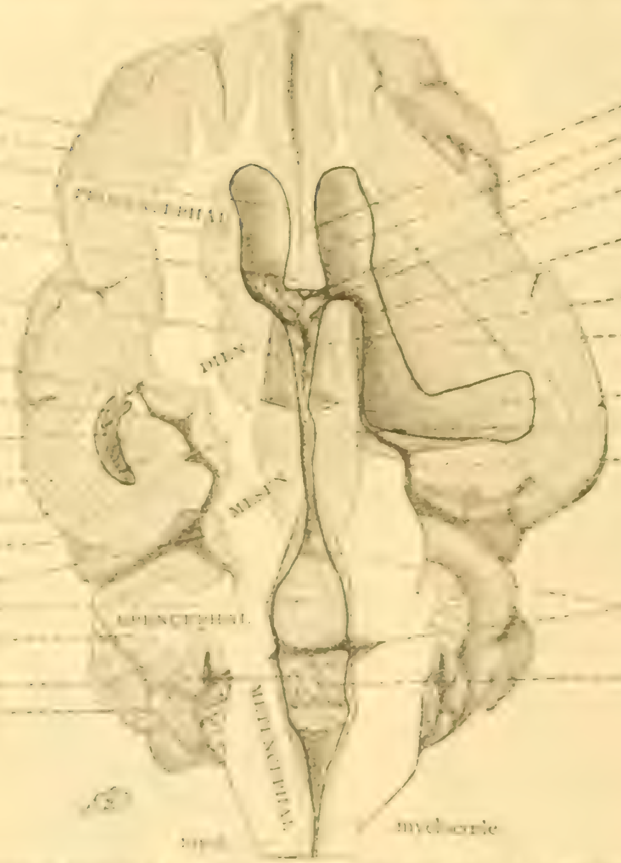

FIG. 4710.—The Encephalic Cavities of a Cat. Exposed from the Ventral Side. [illegible]

[illegible]

C. The different constitution of the various parietes. The roofs of the aula, diacœle, and metacœle are membranous, with plexuses on the ental surface.

D. The reduced thickness of the parietes near the rima, constituting the fimbria, one of the riparian or marginal parts.

E. The apparent interruption of the wall of the mesocœle at the rima (great transverse fissure); on close examination, however, although the proper nervous parietes are absent, the intruded plexus fold (paraplexus) is seen to be covered by the endyma reflected from the adjoining parts, so that the injected alcohol was completely confined.

F. The not very obvious relation of the ectal furrow, hippocampal fissure, to the ental elevation or colliculus, hippocamp; on the right the line from *postgeniculum* crosses the end of the fissure, which is not otherwise indicated.

G. The relations of the alba (medulla) to the ectocinerea (cortex) and the entocinerea ("central tubular gray"); the metepencephalic entocinerea has been removed in exposing the cavities, but it is distinct and abundant at the sides of the mesocœle (aqueduct), of the diacœle, constituting the thalamus, and of the prosencephalic precornu, constituting the caudatum and—unexpectedly—the hemiseptum and fornicolumn, all which were distinctly gray in the fresh preparation.

H. The caudal extension of the cerebrum so as to reach the cerebellum, and thus conceal the lateral aspect of the intervening segments, diencephal and mesencephal.

I. The fusion of the thalamus with the caudatum, of the diacœlian side-wall with the paracœlian floor; the line of junction of the two segments may be regarded as indicated approximately by the word *dien*.

J. The absence or inconspicuousness of the lenticula, claustrum and insula (compare Fig. 4731).

K. The less width of the diencephal than in man, so that the geniculums maintain their proper morphological relation of cephalic (pre) and caudal (post), rather than of lateral, or "external," and mesal, or "internal," as in man.

L. The extension of the paracœles, the proper cavities of the hemicerebrums caudad from the aula even farther than cephalad, thereby warranting the diagrammatic representation of the paracœles as lateral extensions, not cephalic only.

M. The absence of a postcornu in the cat, as in most other mammals, the exceptions being man, monkeys, seals, porpoises, and some, if not all, dogs.

N. The distinctness of the fornicrista in the cat; it is not named on the figure, but may be seen as a conical elevation at the cephalic side of the aula.

§ 58. Prop. XXXV. A convenient classification of the encephalic parts, as in the following Table, assigns them first to the segments in which, at least provisionally, they may be held to belong; second, to the floor, sides, and roof of the segments; third, to categories according to their thickness or other feature; from the nature of the case, several parts may be named more than once; on the other hand, some are omitted altogether.

Provisional Classification of Encephalic Parts according to Segments, Relations to Cavities, and Other Characteristics.

Segments and chief parts.	PROSENCEPHAL: Cerebrum.	DIENCEPHAL: Thalami.	MESENCEPHAL: Gemina.	EPENCEPHAL: Cerebellum.	METENCEPHAL: Postoblongata.
General cavities	Prosocœle	Diacœle	Mesocœle	Epicœle	Metacœle.
Cavitary divisions	Paracœle, porta, aula, cornu.	Aulix, infundibulum		Lateral recess.	
Floors	Fornix, caudatum	Torus, etc.	Crura	Preoblongata and pons.	Postoblongata.
Sides	Hemiseptum, etc.	Thalami	Gemina	Peduncles	Restis, clava.
Roofs	Aulatela and callosum	Diatela	Gemina and valvula.	Cerebellum and lingula.	Metatela, obex.
Commissures and decussations.	Callosum, precommissure, fornix.	Medicommissure, supracommissure, chiasma.	Postcommissure	Pons	Decussation of pyramids; dorsal and ventral commissures.
Marginal parts	Tenia, fimbria, pala	Habena			Obex and ligula.
Telas	Aulatela	Diatela			Metatela.
Plexuses	Prosoplexus	Diaplexus		Epiplexus.	Metaplexus.
Atrophied parts	Prosoterma	Torus	Valvula	Lingula	
Appendages	Olfactory bulb (?)	Conarium, hypophysis		Flocculus and paraflocculus.	
Ental elevations	Caudatum, hippocamp, calcar, collateral, occipital and callosal eminences.	Habena			
Ectal elevations	Gyres, insula	Pulvinar, pregeniculum, postgeniculum, albicans.	Postgeminum, pregeminum, postbrachium, prebrachium, cimbia.	Folia	Oliva, clava, tubercle of Rolando.
Ectal depressions	Fissures	Trigonum, habenal, fimbrial, and tenial sulci.	Lateral sulcus	Peduncular sulcus, rimulæ, prepeduncular fossa.	Postfovea.
Ectocinerea	Cortex		Cappa	Cortex.	
Parts of ectocinerea	Claustrum, amygdala, lenticula.				
Entocinerea	Caudatum		Aqueduct cinerea.		
Parts of entocinerea		Habenar ganglion, etc.		Fastigatum, embolus, globulus, dentatum.	
Other parts		Precribrum, postcribrum.	Intercalatum	Arbor.	

§ 59. Points illustrated by Fig. 4711.—A. The bloodvessels are fully discussed elsewhere in this volume and only three matters connected therewith are referred to here: 1, The presence of a subfalcial sinus marked (2) on the figure; according to Browning ("Veins of the Brain," p. 21), this is often absent, but here, as in some other preparations examined by the writer, it reaches a point a little cephalad of the middle of the length of the callosum where it receives several considerable veins, not shown in this figure; 2, the absence of a distinct precommunicant ("anterior communicating") artery, as in most of the brains examined by the writer with reference to that point; the two precerebral arteries simply converge, join, and again diverge just dorsad of the chiasma; in this preparation the caudal of the two orifices, crossed by the line from the precommissure, represents the place of junction of the two precerebral arteries; the cephalic orifice, just cephalad of the line from *aula*, was caused by the partial slicing off of the right precerebral, part of its wall appearing between the two orifices; 3, the termatic artery springs from the place of junction of the two precerebrals, or from the middle of the precommunicant, when this distinctly exists; its course has not been fully followed out; in this specimen it is soon concealed by the precerebral.

B. This figure also illustrates many of the strictly encephalic points presented in connection with Fig. 4684, which should be compared with this and with the excellent though incomplete representation of the mesal encephalic cavities in Quain's "Anatomy," ii., Fig. 290; frequent reference should be made to the representations of the base and transections of the brain (Figs. 4689 and 4751).

C. It is to be noted that the segmental names are omitted and that the names introduced apply to the parts as such. Most of the cavities are designated by their general titles, metacœle, etc., but the diacœle is not named at all, and the mesocœle is called aqueduct.

§ 60. Prop. XXXVI. *Cœlian circumscription.*—The facts of development and comparative anatomy, and analogy with other hollow organs warrant the presumption that the encephalic cavities communicate only with one another and with the myelocœle. Any communication with the ectal surface is presumably artificial, ex-

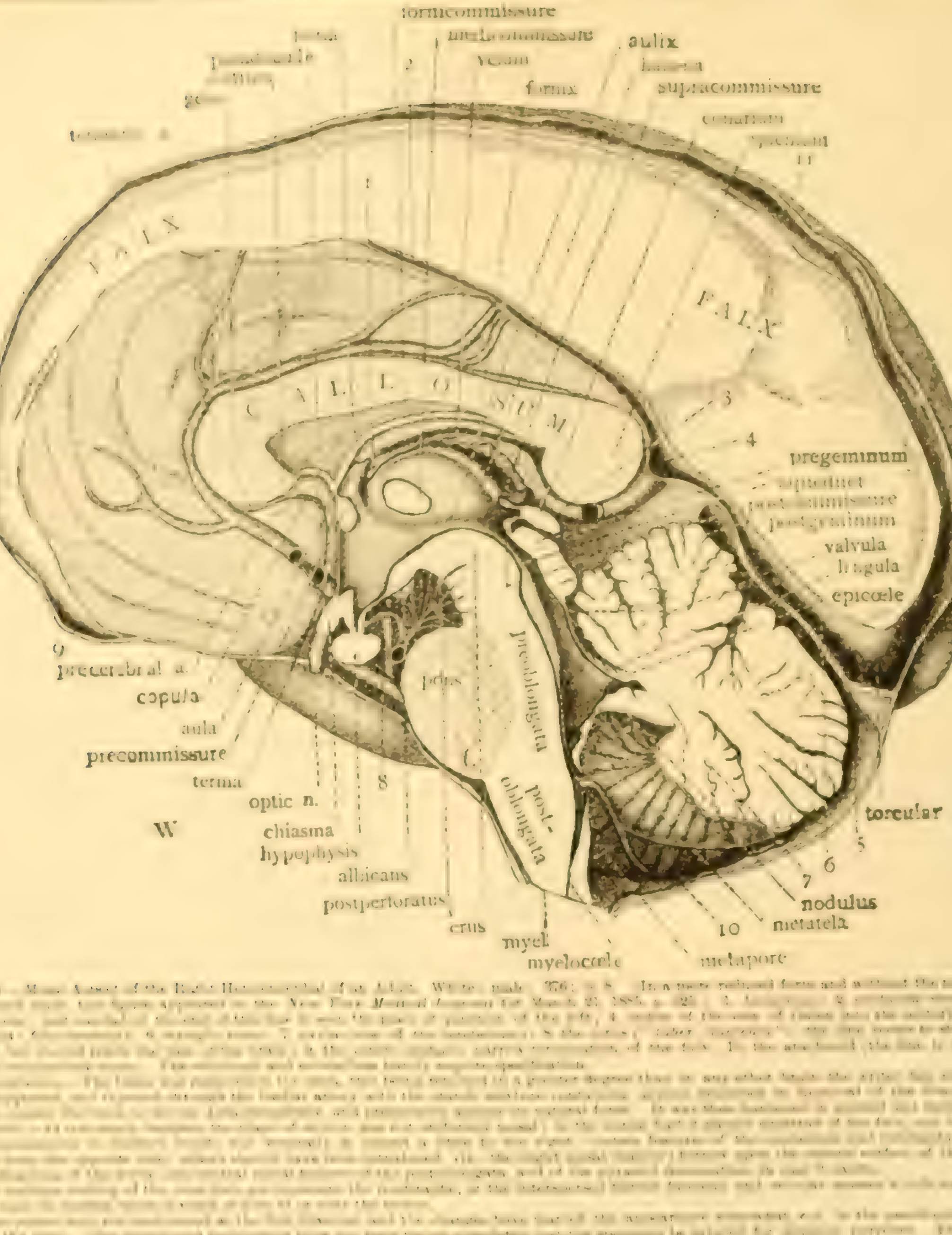

FIG. [illegible].—Mesal Aspect of the Right Hemicerebrum of an Adult White, male. [illegible]

cepting only the metapore ("Foramen of Magendie") which undoubtedly exists in man, though not perhaps in other vertebrates.

§ 61. Prop. XXXVII. *Endymal continuity.*—The endyma is the essential and absolutely constant constituent of the cœlian parietes; hence, in all figures purporting to illustrate cœlian circumscription the line representing the endyma should be distinct and uninterrupted, excepting of course at the metapore.

§ 62. Prop. XXXVIII. In tracing the continuity of the endyma upon the meson, it is best to begin with a region where a rupture could hardly occur in either fresh, [illegible], or older, and where also a transection is most readily effected when the entire brain is to be studied in two parts, a cerebral and a cerebellar portion. This "place of election" is the aqueduct (*iter a tertio ad quartum ventriculum*), the slender adult human remnant of what was in the embryo and remains in some other vertebrates a "vast and spacious cavity" of the most conspicuous portion of the brain.

A. The endyma covering the floor of the aqueduct may be traced caudad (actually almost directly ventrad) with slight depressions and elevations through the oblongata to the myel where it lines the slender myelocœle, the "canal of the cord."

B. Recommencing at the same point in the aqueduct, the floor endyma turns quite sharply ventrad over the cephalic curvature of the crus, passes the albicans and reaches a region where the floor is thin and frequently torn in removing the brain; this is the torus, commonly called "*tuber cinereum*," which is continuous with the tube, infundibulum, and thus with the hypophysis. The cephalic part of the torus joins the chiasma, the ental margin of which presents a marked transverse ridge, sloping caudad into the torus and cephalad into the optic recess. In Figs. 4712 and 4728, the chiasma and torus are shown with the hypophysis attached, but in Fig. 4689 it is detached, leaving an orifice, the lura.

C. Directly dorsad from the chiasma, the cephalic wall of the diacœle is the terma (*lamina terminalis*, or *l. cinerea*) so thin and delicate as to be not infrequently ruptured during the removal or manipulation of the brain; the proper nervous material of the terma seems hardly more substantial than the lining endyma and the covering pia, here represented by the ental and ectal lines; the ectal aspect of the terma is shown in Fig. 4726.

D. Suddenly there is a marked thickening of the cephalic wall, from the reinforcement, so to speak, of the terma by a fibrous cord, oval or elliptical in section; this, the precommissure, connects portions of the cerebrum upon opposite sides, and hence belongs to the prosencephal, and the cavity just caudad and dorsad of it is the aula, the mesal portion of the prosocœle.

E. From the precommissure caudad to the roof of the aqueduct the course of the endyma is extremely irregular, and the nature and shape of the roofs very diverse; the immediate roof is largely membranous, and the condition is further complicated by blood-vessels large and small, and by plexuses; finally, the parts lying directly upon the meson differ materially from those just laterad of it, and as the chances are altogether against a medisection being exactly mesal in the whole of its course, there is nearly a certainty that upon the first inspection one will miss anticipated features and see what one does not understand.

F. The recognition and comprehension of the actual facts in a given preparation will be facilitated by recalling the diagrams (Fig. 4706), and the representations of the brains of the cat and rabbit (Figs. 4710 and 4694). The important point to bear in mind is that the complete circumscription of the mesal encephalic cavities would be unaffected were the entire cerebrum removed, including the callosum, hemiseptum (the lateral wall of the pseudocœle), and fornicommissure (the mesal continuity of the fornix), down to the point where the heavy line representing the endyma leaves the narrow, white area representing the fornicommissure to cross the convex surface of the fornicolumn and be reflected upon the auliplexus. The details of this, the aulic and portal region, are more clearly seen in an enlarged figure of the porta, in the article Malformations of the Brain.

G. From the auliplexus (at or very near the meson) or from the portiplexus (if the section-plane passes through the right or left porta instead of the mesal aula) the endyma may be traced caudad upon the ventral surface of a membranous fold, the velum. Strictly speaking, between the endyma and the velum, which is a fold of pia, intervenes the remnant of the primitive nervous roof of the diacœle; this may persist in some animals, but in the adult cat and in man, so far as the writer is aware, there is practically nothing between the pia constituting the velum and the endyma. At each side of the meson there depends a more or less distinct vascular fringe, the diaplexus, continuous with the auliplexus, the portiplexus, and thus with the paraplexus, these last three being successive members of the prosoplexus.

H. The relations of the endyma to the velum and plexuses are more clearly shown in Fig. 4751, representing a transection of the diacœle. There also are shown the relations of the habena. This is a low ridge following a curved line along the mesal aspect of the thalamus from the dorsal end of the porta to near the conarium; it is covered by endyma, but just dorsad of it, dimly seen in the figure, is a shallow furrow, the habenal sulcus, from which the endyma is reflected first dorsad, and then mesad, upon the velum and the diaplexus. The habena unites with its opposite fellow of the other side at the supracommissure. The endyma line is seen to leave the velum, and descend to the dorsal (really cephalic) surface of the conarium, whence it extends cephalad to and over the margin of the supracommissure, then into and out of the conarial recess, and over the convex cephalic surface of the postcommissure, whence it enters the aqueduct, where the tracing of its continuity was begun, only it is now the lining of the roof, the geminal bodies, instead of the floor.

I. Continuing caudad, there is but slight change in the direction of the roof of the aqueduct; a great reduction in its thickness occurs in the transition from the postgeminum to the valvula; the succeeding part, the lingula, is somewhat thicker and trends slightly dorsad, to become continuous with the cerebellum proper. The cavity here resembles a gable roof, with a sharp dorsal angle. The caudal slope is formed by the nodulus, a comparatively massive mesal lobe; but from its margin, commonly more rounded than appears in this figure, the endyma is abruptly reflected, together with the pia which had covered its caudal surface; these two membranes, closely united, and with apparently little or no trace of the primitive nervous roof, constitute the metatela. This is suddenly interrupted by the orifice here called metapore, but commonly known as "foramen of Magendie," see Hess, in *Morphologisches Jahrbuch*, vol. x.; in the present figure it is at the point where an artery appears; caudad of the metapore, the metacœlian roof is a thin lamina, the obex, which is continuous with the dorsal commissure of the oblongata and that of the myel, constituting the roof of the myelocœle.

§ 63. Prop. XXXIX. *Encephalic variations.*—Excepting as to the fissures and gyres, and the pyramidal decussation (well discussed in *Quain*, ii., 278 and 289), treatises upon anatomy seldom refer to variations or anomalies of the surfaces or ental structures of the brain, yet they are frequent, and sometimes significant, morphologically if not physiologically. So far as the present writer can determine from his own materials, and from figures and descriptions, there is hardly a feature of the human brain respecting which it can be stated confidently what is normal, or how frequently certain peculiarities occur.

The foregoing account of the brain as a whole constitutes an introduction to the description of each of the five segments, beginning with that immediately succeeding the myel.

§ 64. METENCEPHAL.—Synonyms: Metencephalon, after-brain, myelencephalon, macromyelon.

Tabular arrangement of parts.—Chief part: postoblongata (caudal portion of "medulla oblongata"). Cavity: metacœle (caudal portion of "fourth ventricle"). Floor: postoblongata. Sides: restes ("restiform bodies") and ligula. Roof: metatela and obex. Plexuses: metaplexuses. Orifice: metapore ("Foramen of Magendie"). Decussation: Dec. of the pyramids. Other ectocœlian parts and features: Ventral sulcus; ventral column; pyramid; oliva; arciform fibres; lateral column; funiculus of Rolando; tubercle of Rolando; cuneate funiculus; *funiculus gracilis;* clava; ligula; obex. Other entocœlian parts and features: Mesal sulcus; *ala cinerea;* postfovea; *eminentia cinerea.*

§ 65. Prop. XL. The postoblongata (Figs. 4684, 4689, 4712, 4713, 4719, and 4721) is so obviously a continuation of the myel that if there were no parts cephalad of it, and if it were wholly contained within the spinal canal, it would probably be regarded as merely a somewhat modified region of the myel, comparable with the lumbar enlargement near its other extremity, which also in birds contains a distinct and thin-roofed dilatation, the rhombocœle. There is, therefore, ample warrant for the name *macromyelon* (large myel region), applied by Owen, and for *myelencephalon* (myel-like brain region), employed by Huxley. On account, however, of its equally obvious continuity with the preoblongata (especially in animals lacking the pons), its location, mostly within the cranium, and the number, peculiarity and vital importance of the [illegible] connected with it, the postoblongata is [illegible] regarded as a division of the brain, [illegible] the segmental [illegible].*

§ 66. Points illustrated upon Fig. 4712.—A. The ectal origins of the cranial nerves (see Vol. V., Fig. 3024).

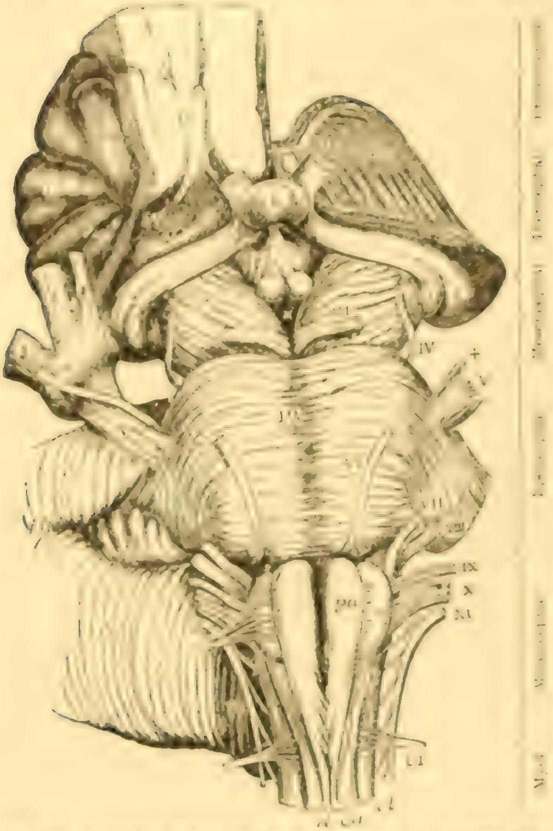

Fig. 4712.—Ventral Aspect of the Human Brain-stem. × 1. (From Quain; compare Fig. [illegible].) The Roman numerals I.–XII. designate the ectal origins of cranial nerves, described in Vol. II. [illegible] internal [illegible]

B. The ventral aspect of the adult insula (comp. Figs. 4689, 4782, and 4784).

C. The continuity of the optic tract with both geniculums.

D. The decussation of the pyramids (see under Fig. 4689).

E. The representation of all five segments upon the ventral aspect of such a preparation, including the parts of what is commonly called the "brain-stem."

F. The overlapping of the more cephalic fasciculi of the pons upon the more caudal (comp. Fig. 4713).

§ 67. Prop. XLI. The postoblongata differs from a corresponding length of the myel in size, shape, amount of alba, amount and arrangement of cinerea, extent and and form of the cavity, and the nature of its roof.

§ 68. Prop. XLII. In the myel the two halves dorsad of the commissures are in contact. This is the case also with the caudal extremity of the postoblongata; but for most of its length the originally mesal surfaces are separated by a rapidly widening interval, so that what was mesal becomes successively dorsal, and finally lateral, while what was lateral becomes approximately ventral. These changes materially increase the width of the segment.

§ 69. Prop. XLIII. The cavity, a tube in the myel and caudal part of the postoblongata, is expanded into an irregular triangular fossa, the metacoele or caudal part of the fourth ventricle. The roof of this cavity has lost its true nervous character and consists of only the lining endyma and the covering pia, constituting the metatela.

§ 70. Prop. XLIV. The increased cinerea of the postoblongata consists of (1) the continuous expanded masses of the ventral and dorsal cornua, especially the latter, which, with the modified ventral commissures, constitute the metacoelian floor; (2) special masses of cinerea, more or less completely separate, the nuclei of Spitzka, the "nuclei" of most writers, constituting the ental or deep origin of certain cranial nerves (Vol. II., Fig. 766) and presumably representing detachments of the cornua; (3) the dentoliva (*dentatum olivæ* or olivary nucleus), a capsule of cinerea within the oliva resembling the cerebellar dentatum (see in the next article on Histology of the Brain).

§ 71. Points illustrated upon Fig. 4713.—A. The insensible transition from the myel to the postoblongata, and thus from the myel as a whole to the brain as a whole.

B. The apparently sharp demarcation between the epencephal, represented here mainly by the pons, and

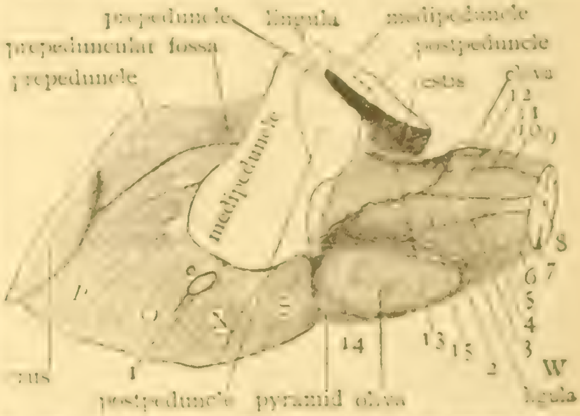

Fig. 4713.—Left Side of the Metencephal (after the Removal of the Cerebellum) [illegible]

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* [illegible]

the adjoining segment; in reality, however, not only do the cephalic and caudal margins overhang the adjoining surfaces to a certain extent (see Fig. 4719, 1 and 2), but it is by no means certain that the pons covers no more and no less than the epencephalic portion of the oblongata; in the cat, for example, the trapezium, here invisible, is exposed, while with many lower vertebrates the pons is rudimentary or absent altogether, and the boundaries between metencephal and epencephal must be otherwise determined.

C. The lapping of the cephalic portion of the pons over the caudal, giving the appearance of a twist or rotation of the medipeduncle upon its own axis to the extent of the fourth of a circle.

D. The relation to the oliva of the arciform fibres (2), which appear to be derived from the pyramid and to pass around the caudal end of the oliva to enter into the composition of the restis and postpeduncle.

E. The projection of the right clava beyond the left, a marked lack of symmetry in this specimen.

F. The ligula, or line of demarcation between the general, pial surface of the myel and oblongata, and the endymal, metacœlian surface; the ligula consists of the pia and endyma with, in some specimens (Fig. 4719), a thin intervening lamina of nervous substance.

G. The prepeduncular fossa, a shallow depression on the dorso-lateral surface of the prepeduncle, near the medipeduncle.

§ 72. Prop. XLV. The visible longitudinal divisions of the postoblongata do not correspond altogether with the myelic columns. The following account of the principal differences is condensed and modified somewhat from *Quain*, ii., 286, 288, 298.

§ 73. Prop. XLVI. The ventral column (Fig. 4689, *i*, Fig. 4712, *ca*, Fig. 4713, 6) continues cephalad partly in the pyramid of the same side, as would naturally be expected, but mostly dips entad of the pyramid and oliva and forms longitudinal fasciculi near the meson farther dorsad.

§ 74. Prop. XLVII. Of the lateral column (Fig. 4712, *cl*, and Fig. 4713, I) a large part crosses at the decussation (shown in Fig. 4712, but not always visible) to constitute mainly the pyramid of the opposite side; some of the fibres join the restis of the same side, constituting the "direct lateral cerebellar tract;" the rest of the lateral column dips entad of the oliva and "forms the longitudinal fibres of the *substantia reticularis grisea.*"

§ 75. Prop. XLVIII. The dorsal column of the larger portion of the myel is displaced in the cervical region by the dorso-mesal ("posterior median") column (Vol. II., Fig. 760; Fig. 4713, 10); this, in the postoblongata, is called *funiculus gracilis;* near the apex of the metacœle it presents a distinct enlargement, the clava (Fig. 4713), cephalad of which the funiculus is no longer distinct. Between the *funiculus gracilis* and the lateral column (Fig. 4713, 4) there intervene, in the postoblongata, two funiculi, of which the more lateral (15) is regarded as the direct continuation of the dorsal column of the myel, but is commonly called funiculus of Rolando, sometimes "lateral cuneate"; between it and the dorso-mesal column (*funiculus gracilis*) intervenes another interpolated funiculus, the cuneate (12); this and the funiculus of Rolando appear to enter into the composition of the restis ("restiform body") which is continued as the postpeduncle into the cerebellum; but, according to *Quain*, ii., 288, this relation is rather apparent than real, the components of the restis and postpeduncle being (*a*) the arciform fibres (Fig. 4713, 2) from the ventral column, and (*b*) the "direct cerebellar tract" of the lateral column.

§ 76. Prop. XLIX. The increased bulk of the postoblongata is due also in part to the entrance (or exit) of the roots of the accessory, hypoglossal, vagus, and glossopharyngeal nerves, which are more numerous than the spinal nerve roots upon a similar length of the myel; see Figs. 4689, 4712, and Vol. II., Fig. 760.

For fuller details of the structure of the postoblongata see the next article on Histology of the Brain.

§ 77. EPENCEPHAL.—Synonyms: Epencephalon, hindbrain. Tabular arrangement of parts: Chief parts: cerebellum. Cavity: epicœle (cephalic portion of "fourth ventricle"). Floor: preoblongata and pons. Sides: peduncles. Roof: cerebellum and lingula. Lateral extensions: parepicœles. Ectocinerea: cortex. Entocinerea: dentatum, fastigatum, globulus, embolus. Main cerebellar divisions: vermis and lateral lobes. Other parts and features are named upon the figures.

§ 78. Prop. L. The *cerebellum* is essentially an arch over the epicœle (cephalic part of the "fourth ventricle"); Figs. 4697 and 4714. This condition exists in the embryo, and persists in many of the lower vertebrates. The adult human organ, however, is a foliated mass of complex fibrous and cellular structure, well meriting the adjective, *hypertrophied*, applied to it by Spitzka.

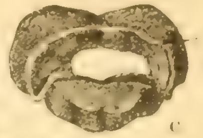


FIG. 4714. Caudal Aspect of the Epencephal (Cerebellum) and Preoblongata of a Fœtus. (Size and age and magnification uncertain, specimen and notes having been lost; it probably resembled quite nearly the specimen shown in Fig. 4697.)

§ 79. Points shown upon Fig. 4714.—A. The large size of the epicœle at this period, as compared with the thickness of the parietes.

B. The extensions latero-ventrad constituting the parepicœles or "lateral recesses" (comp. Figs. 4702 and 4703).

C. The non-appearance of the mesal lobe, vermis, at this period.

D. The continuity of the riparian part, *a*, along the line of junction of the ectal pia and ental endyma, they not being represented distinctly.

§ 80. Prop. LI. The adult cerebellum comprises a mesal lobe, the *vermis*, and two *lateral lobes*, sometimes called "hemispheres." On the cephalic aspect, the vermis (prevermis) is prominent (Fig. 4716); but on the caudal the lateral lobes project decidedly beyond the postvermis, the surface of which is thus at the bottom of a deep mesal crevice, the *vallecula* (Fig. 4717). The cephalic and caudal regions of the cerebellum, both lateral lobes and vermis, are separated, though not completely, by a deep cleft, commonly called the "great horizontal fissure," but here named *peduncular sulcus* from its obvious relation to the medipeduncle at each side (Figs. 4715, 4716, and 4717).

§ 81. Prop. LII. *Folia*, *rimulæ*, and *lobes*.—The entire surface of the adult cerebellum presents numerous lines, for the most part parallel and having a generally transverse direction. These lines represent crevices of greater or less depth, the rimulæ, and the intervening thin plates are the folia. Certain of the interfoliar crevices are so deep or so distinct as to warrant the recognition of the intervening groups of folia as lobes.

§ 82. Points illustrated upon Fig. 4715.—A. The general form and foliation of the lateral aspect of the cerebellum. The flocculus is seen in the interval between the pons and the oliva, and the peduncular sulcus, dividing the cephalic from the caudal region, is represented by the rather heavy line beginning at the flocculus and ending at the dorsal margin, where it is intersected by the line 13.

B. As upon the mesal aspect (Fig. 4718), the remarkably complete fissuration in a child at term.

C. The perfect exemplification of the typical relations of the insula, the operculums and the Sylvian fissure; compare the fœtal brains (Figs. 4759, 4760, 4762 and 4782) and the adults (Figs. 4767, 4778 and 4779) in which the presylvian and subsylvian fissures are united for a certain distance.

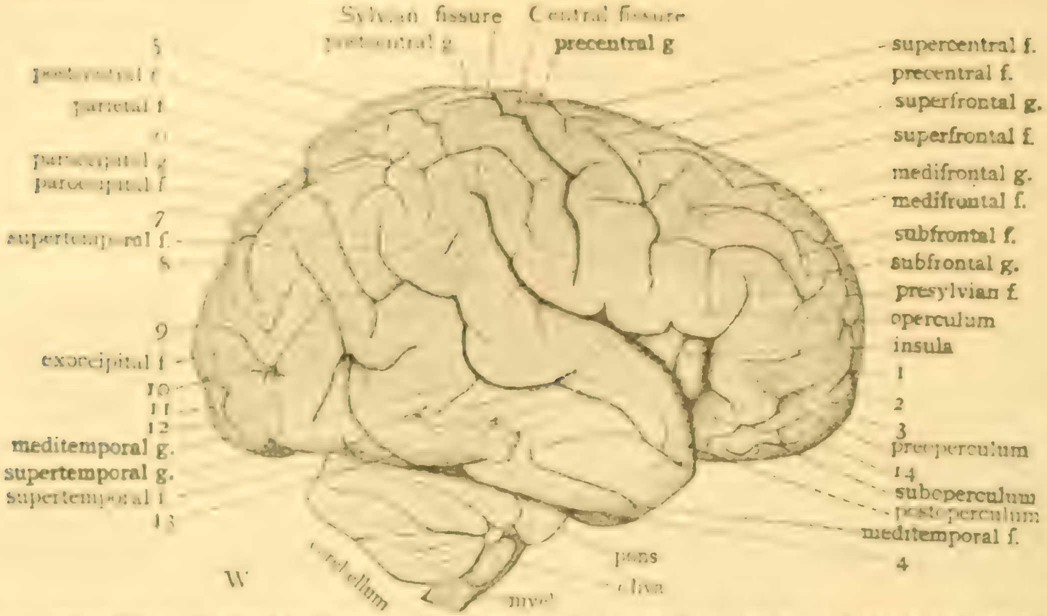
D. The presence of a distinct medifrontal fissure, subdividing the medifrontal gyre.

E. The independence of the postcentral, parietal, and paroccipital fissures (see also Fig. 4774).

F. The presence of the exoccipital (the "ape fissure" of some writers)

G. The frequency of the zygal or H shaped form of fissure; *e.g.*, paroccipital, parietal, postcentral, subfrontal, orbital, and fissure 1.

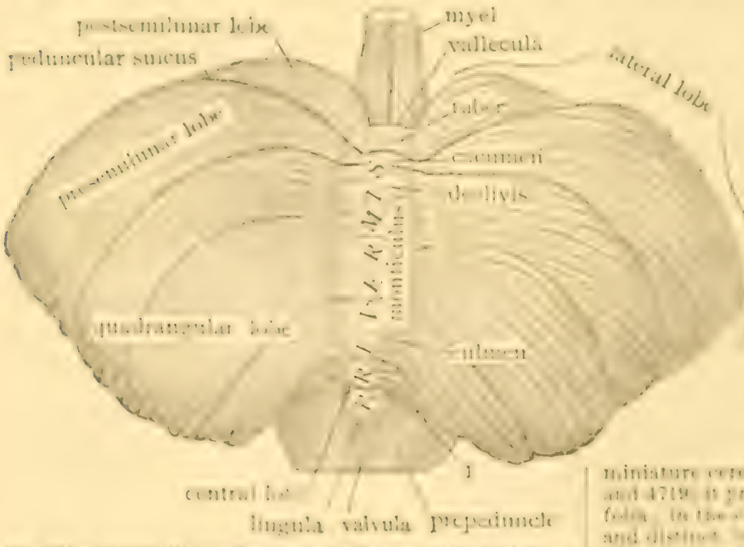
§ 83. Prop. LIII. The commonly received division of the two regions of the cerebellum into lobes is indicated



[illegible]

upon the figures. The writer is free to admit, however, that he is by no means fully satisfied therewith.

§ 84. Points illustrated by Fig. 4716.—1. The natural tilt caudad of the cerebellum so that its normally cephalic surface looks dorso-cephalad even when the oblongata is held in the cephalo-caudal plane.



[illegible]

2. The extension of the cerebellum so as to overhang the postoblongata.

3. The enormous preponderance of the lateral lobes over the mesal lobe (vermis) in the adult; compare, however, Fig. 4697, and, in Vol. I., Fig. 512.

4. The slight demarcation between the vermis and lateral lobes on this aspect.

5. The appearance of part of the postsemilunar lobes, and of the peduncular sulcus, both these appearing partly also upon the caudal surface.

6. The connection of the two presemilunar lobes by means of a single folium, the cacumen, not always present.

§ 85. Prop. LIV. *Lingula.*—Between the substantial postgeminum and the massive cerebellum the roof of the continuous mesocoele and epicoele is constituted by a relatively insignificant lamina, the valvula and the lingula. The former will be considered in connection with the rest of the mesencephal; the latter may be regarded as a miniature cerebellum. In medisection (Figs. 4711, 4718, and 4719) it presents several (3-5) elevations, cerebelliform folia. In the child at birth the lingual folia are rounded and distinct, but in the adult they are relatively smaller, often flattened as if by pressure of the overhanging cerebellum and sometimes (at least in certain insane brains) nearly or completely absent. The cephalic folium is narrowest and has a rounded outline (Fig. 4716); the pia adheres quite firmly to these folia, so that they are liable to be torn off.

§ 86. Points illustrated upon Fig. 4718.—A. In connection with Figs. 4715 and 4719, the perfection and beauty of form of the human brain at birth.

B. The relatively small size of the cerebellum at birth.

C. The distinctness and prominence of the pons.

D. The lateral extent of the pseudocœle; at the genu (cephalic curvature) of the callosum it is 1 mm. deep, representing about one-half of its entire lateral extent.

E. The continuity of the callosum and fornix.

F. The distinctness and depth of the principal fissures and the large number of minor ones.

G. The peculiar ventral curve of the caudal half of the calcarine fissure, and the concomitant expansion of the cuneus.

H. The length of the fissure in the subcalcarine gyre.

I. The appearance of the cephalic stipe of the paroccipital fissure (18) upon the mesal aspect; compare Figs. 4773, 4774, and 4776.

§ 87. Points illustrated by Fig. 4719.—A. The mesal topography of the cerebellum and adjacent parts when brought into nearly their "normal position," *i.e.*, when the metepencephalic floor is nearly horizontal (cephalocaudal) and when the longer axis of the cerebellum is nearly dorso-ventral; this is nearly their condition in a body lying prone, with the axon and longer portion of the neuraxis (myel) approximately horizontal, as with most quadrupeds and the majority of walking and swimming vertebrates (see § 3, I, and the article on Anatomical Terminology). For comparison with Figs. 4684, 4711, and 4718, this or they must be regarded as turned about one-fourth of a circle.

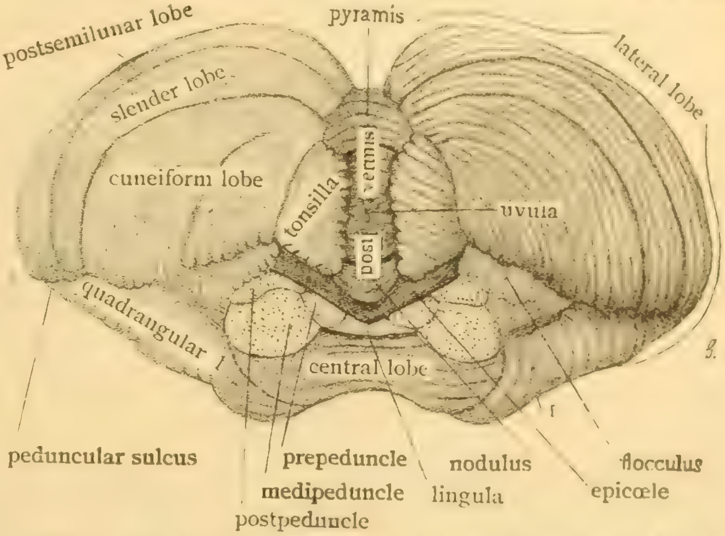


FIG. 4717.—Caudal ("lower" or "posterior") Aspect of the Adult Cerebellum. A little less than natural size; from Edinger, inverted and slightly modified. 1, Part of the right quadrangular lobe. The cut ends of the peduncles are dotted; the large medipeduncles extend latero-dorsad into the lateral lobes; the flocculi are attached to the medipeduncles. The continuity of the vermian divisions with those of the lateral lobes is not apparent upon this aspect.

Defects.—In addition to the general remark made under Fig. 4716 the following special deficiencies are to be noted: 1, There is no line to represent the divided endyma of the metatela along the caudal (here upper) side of the cavity (epicœle); all this region requires elucidation in respect to cœlian circumscription; 2, the omission of the plexuses and nerve roots; 3, the postvermis should be more deeply shaded to indicate its depth below the level of the tonsillæ, which also are really almost in contact; 4, on this, or on Fig. 4716, the vermis should present a line indicating the reflection of the arachnoid.

B. The exact number and form of the cerebellar folia and subfolia at birth, so far as they appear upon an approximate medisection.

C. The combination of the folia to form lobes, more or less well defined.

D. The arboriform arrangement, whence the name *arbor vitæ* (herein mononymized to *arbor*).

E. The topographical relations of the mesal lobe (vermis) to the lateral lobes; caudad, dorsad and at the ventro-cephalic region the lateral lobes project beyond the vermis, but the latter is the more prominent with the culmen at the cephalic side and with the nodulus at the caudo-ventral angle. The interval between the lateral lobes on the caudal aspect constitutes the vallecula.

F. The depth of the peduncular sulcus, and the coincidence of its general direction with that of the hypercœle (6), dividing the "stem" of the arbor (*corpus trapezoides*) into a preramus ("vertical" branch) and a postramus ("horizontal" branch).

G. The similar division of the folia of the mesal lobe into a prevermis ("superior" vermiform process) and a postvermis ("inferior" vermiform process).

H. The enormous size of the cerebellum as compared with its cavity, even had the dorsal part of the latter (hypercœle) been maintained at its natural size by alinjection.

I. The projection of the cerebellum beyond its attachments and proper cavity. Cephalad, it overhangs not only the valvula but the postgeminum, these being parts of the mesencephal; caudad, whatever exact limit be assigned to the epicœle, the vermis covers the entire "fourth ventricle," and the lateral lobes.

J. The distinctness of the four lingular folia, constituting the transition from the massive cerebellum to the atrophic (?) valvula.

K. The apparent absence of the cacumen, the single folium which, when present, rises from the bottom of the peduncular sulcus and connects the presemilunar lobes of the two sides. According to Henle, it is not constantly present.

L. The prominence of the cephalic and caudal margins of the pons, and the concomitant depth of the prepontile and postpontile recesses.

M. The merging of the dorsal commissure of the myel and postoblongata into the obex, and of this into the lingula; in the adult this latter seems to be hardly more than the combined pia and endyma (see Fig. 4713), but in the child's brain from which this feature was derived, although the meninges had been removed, there was, nevertheless, a distinct lamina of nervous substance.

§ 88. Prop. LV. The adult *epicœle* is extremely irregular in form; the main portion is a direct and slightly narrowing cephalic continuation of the metacœle; there is a cephalic extension covered by the lingula; a dorsal into the cerebellum, the cephalic and caudal slopes of which meet like a gable roof, whence the name *fastigium*; and a lateral at each side, curving ventrad, the "lateral recess" or parepicœle. Neither Fig. 4703 nor any representation known to the writer, fairly indicates the remarkable shape of this portion of the encephalic cavity.

§ 89. Prop. LVI. *Flocculus.*—Attached to the medipeduncle at the beginning of the peduncular sulcus, and wedged, as it were, between the rounded contiguous angles of the cephalic and the caudal regions of the cerebellum (Figs. 4689 and 4717) are three small foliated masses, the flocculus (in two lobes), and the paraflocculus (a single lobe), Fig. 4720. Their functions and their representatives in other mammals are little known. The stem or peduncle of the flocculus forms one of the sides of the lateral recess (Fig. 4720).*

§ 90. Points illustrated upon Fig. 4720.—A. The location and form of the flocculus, with its two divisions and rounded folia, and of the smaller paraflocculus, presenting but slight traces of foliation. All are attached to the medipeduncle, and the flocculus is sometimes called the peduncular lobe.

B. The general location of the lateral recess (2) or parepicœle, between the peduncles cephalad, the restis and other parts of the postoblongata mesad, and the flocculus and lateral. Its peculiar relations with the [illegible] ganglia and [illegible] cortex are inadequately shown and need special preparation and study.

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* Cleland has a suggestive note on the flocculus in "Memoirs and Memoranda of Anatomy," i., p. 174, received while this article is passing through the press.

§ 91. Prop. LVII. *Cerebellar cortex* [illegible].—This forms a layer of remarkably uniform thickness covering the folia, including those of the lingula. It is outlined only in Fig. 4711 but can readily be imagined in the others. Its structure is described in the next article on Histology of the Brain.

§ 92. Prop. LVIII. *Cerebellar* [illegible].—In a median section of the organ there would appear to be only [illegible], the former branching in a tree-like manner, whence the name *arbor vitæ*. But there are reasons for thinking that the primitive cerebellar cortex has been [illegible] and is represented by four pairs of masses which are exposed in sections from the meson to the middle of either lateral lobe. They are figured and described in the following article, and are here merely enumerated in their order from the meson laterad: Fastigatum, globulus, embolus, dentatum: the last is the largest and most easily recognized.

§ 93. Prop. LIX. *Peduncles.*—At and near the mesal the connections of the cerebellum with the adjoining segments are thin; the lingula is relatively [illegible] (Fig. 4719) and the [illegible] (Figs. 4684 and 4711); but laterally it has massive continuations constituting three pairs of peduncles: a cephalic (prepeduncles) to the mesencephal, a caudal (postpeduncles) to the metencephal and myel, and an intermediate (medipeduncles) to the pons, part of the same segment.

§ 94. Prop. LX.—The peduncles constitute a continuous mass of fibres at either side, but their relative positions and extent are pretty well determined by various methods, anatomical, microscopical, and experimental. The medipeduncle is the largest and most lateral. It is mainly continued from the lateral lobe of the cerebellum to the pons, where the fibres cross the mesal, intercalating with their opposites and forming a relation with the cinerea, which will be considered in the following article. The postpeduncle mainly connects the vermis with the restis, while the prepeduncle connects chiefly the dentatum with the mesencephal and parts farther cephalad.

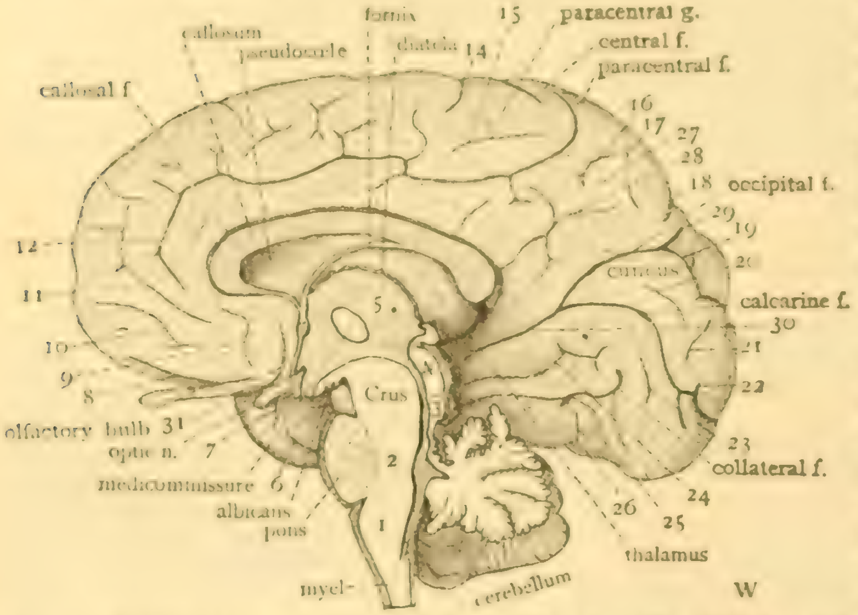

FIG. 4718.—Mesal Aspect of the Right Hemicerebrum of a Male Child, at Term. 478. × .84. Other aspects of the same specimen are shown in Figs. 4715, 4714, and 4776. 1, Postoblongata; 2, preoblongata; 3, postgeminum; 4, pregeminum; 5, thalamus, its mesal surface forming the lateral wall of the diacœle; the [illegible] surface is designated by the line from the word thalamus. These are parts of one and the same [illegible] 6, [illegible]; 7, [illegible] fissure; 8, olfactory fissure; 9, 10, 11, unidentified fissures on the mesal surface of the frontal lobe; perhaps some represent [illegible]; 12, [illegible] fissure, continuous with the paracentral; 13, [illegible]; 15, [illegible]; 16, 17, [illegible] fissures in the precuneus (27); 18, cephalic stem of [illegible] fissure; 19, a ventral branch of the occipital fissure; 20, 21, [illegible] fissures; 22, [illegible] branch of the [illegible] fissure [illegible]; 23, 24, fissures in the [illegible] gyre; 25, 26, fissures in the [illegible] gyre; 28, the [illegible] fissure; 29, dorsal end of the occipital fissure; 30, [illegible] occipital and calcarine; 31, a shallow fissure [illegible]. See § 89.

Preparation.—The fresh brain was [illegible] in brine, and the head was hardened in alcohol [illegible].

Defects.—The specimen [illegible] and is therefore wider and thinner than [illegible]. The [illegible] The thalamus is not distinctly seen. The cerebellum [illegible] Fig. 4776. The hypophysis is lacking, and the [illegible].

chiefly the dentatum with the mesencephal and parts farther cephalad.

§ 95. MESENCEPHAL.—Synonyms: Mesencephalon, midbrain. Tabular arrangement of parts. Chief parts: gemina ("optic lobes"). Cavity: mesocœle (aqueduct of Sylvius). Floor: crura. Sides: gemina. Roof: gemina and valvula. [illegible] Lateral recess: aqueduct ("central" tubular gray). Commissures and decussations: postcommissure, trochlearis.

§ 96. Prop. LXI. In early embryonic stages the mesencephal is the most conspicuous region of the entire brain, but consists of a single, thin-walled vesicle with a relatively large cavity (Fig. 4691). As the parietes thicken, two furrows appear upon the dorsal aspect: a mesal, demarcating the left elevation from the right, and a transverse, subdividing each of these into a cephalic and a caudal portion (Fig. 4697); these result, in the adult mammalian brain, the formation of four approximately similar elevations, whence the names *corpora quadrigemina*, *corpora quadrigemina*, *optic lobes*, etc. In the present article they are called *gemina* (twin bodies) (Figs. 4721 and 4723). They constitute the larger part of the mesocœlian roof.

§ 97. Points illustrated upon Fig. 4723 (see p. 130) under *Diencephal.*—A. The segmental overlapping of the diencephal at the side of the mesencephal and of the prosencephal at the side of that; see § 62, B.

B. The division of the caudatum (the entocœlian portion of the striatum) into a cephalic, enlarged *caput* and a caudal, slender *cauda*.

C. The unlike topographical relations of these two parts, in that the caput is [illegible], while the cauda has a slender, marginal (tæniate) band at its mesal side, the tænia, having peculiar connections with other parts.

D. The location of the diacœle between the two thalami and its continuity with the aula.

E. The presence of the medicommissure (seen somewhat better in Fig. 4727).

F. The relation of the callosal genu to the intercerebral fissure and the pseudocœle: but for the callosum the fissure and the pseudocœle would be continuous, as would also the hemiseptum with the general mesal wall of the precornu.

G. The demarcation of the mesal, entocœlian surface of the thalamus from the dorsal, entocœlian surface by a rough edge just dorsad of the habena; here it is represented by the narrow, white line between the two black ones, and designated as the habena; it is really a ripa along the dorsal side of the habena; see also Fig. 4718.

H. The presence of three shallow furrows on the dorsal surface of the thalamus; a dorso-mesal, just dorsad of the habena, the habenal sulcus; a lateral, corresponding nearly with the mesal edge of the tenia, the tenial sulcus; an intermediate and oblique, corresponding with the lateral margin of the fimbria (removed), the fimbrial sulcus.

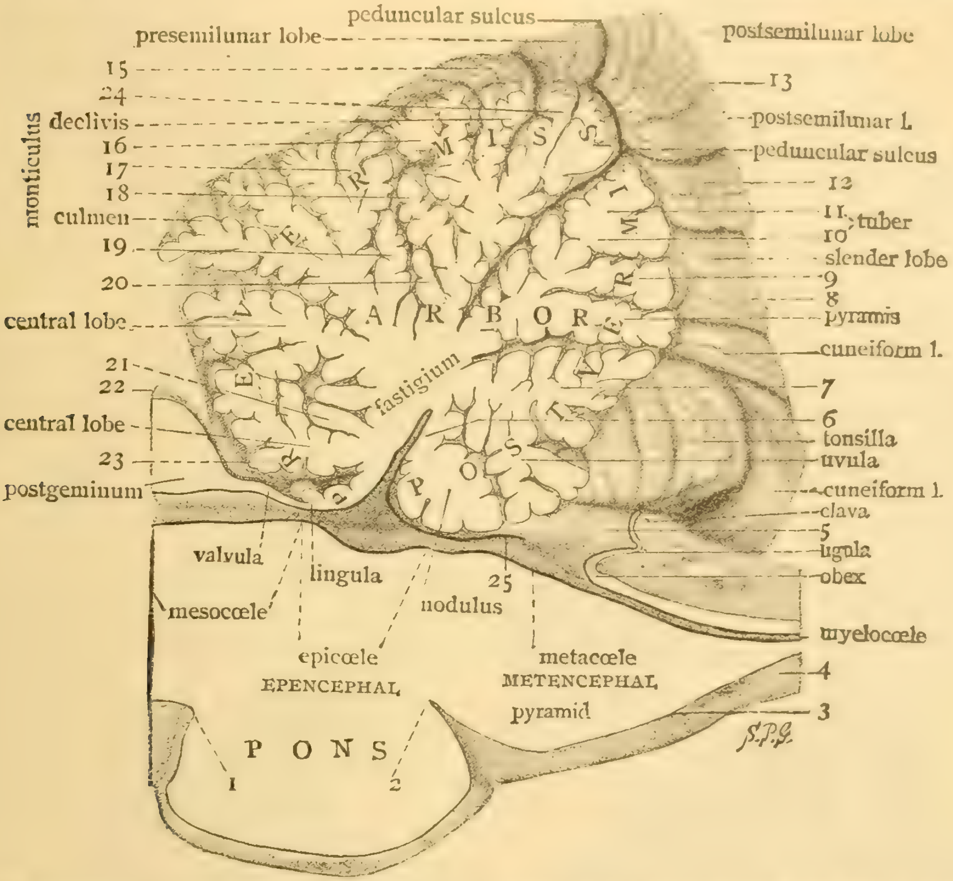

FIG. 4719.—The Metepencephal (Cerebellum, Oblongata, and Pons) of a Child at Term, Showing the Approximately Mesal Aspect of the Right Half. 478; × 3. (This is the same specimen that is shown in Fig. 4718, where, however, no attempt was made to represent details, and the cerebellum is more nearly in its "natural attitude." 1, Prepontile recess; 2, postpontile recess (*foramen cæcum*); 3, presumed caudal end of the pyramid; between 3 and 4 there might be—but were not seen—indications of the pyramid decussation (Figs. 4689 and 4712). 5, slight elevation of the metacœlian floor; the triangular darker area just ventro cephalad represents the postfovea. 6, the dorsal extension of the epicœle into the cerebellum, the hypercœle, or "cerebellar ventricle;" 7, dorsal part of the uvula; 9, dorsal part of the pyramis (*cerebelli*); 10, 11, two divisions of the tuber; 22, retreating dorsal surface of the postgeminum; 24, dorsal folia of the prevermis; 25, metatela (*velum medullare posterius*). the other numbers designate folia or interfoliar sulci which have not been identified or need not be specified in this connection. See § 87.

Defects.—The plane of section passed slightly sinistrad of the meson; hence certain features are not exactly what would have appeared upon a precise medisection. On the cut (unshaded) surfaces the alba and cinerea are not distinguished, the latter having been bleached by the alcohol. The pons section does not show the fibres of the raphé. The cavities were not alinjected and hence are unnaturally small. The meninges were removed; so there is no indication of the dorsal attachment of the arachnoid to limit the subarachnoid space and the obex, ligula, and metatela are supplied from other specimens, but the extent of the metapore (Foramen of Magendie) is not shown. The cacumen cannot be found in the specimen; perhaps its absence should have led to the selection of another preparation as a basis for the figure.

I. The demarcation of the dorsal surface of the thalamus, which is pial and ectocœlian, from the adjoining surface of the caudatum and tenia, which is endymal and entocœlian, by a sharp, irregular line at the mesal edge of the tenia, constituting a ripa. (This line was introduced into the figure; it is absent in the original, as in all similar figures known to the writer, excepting Fig. 16, in Meynert's "Psychiatry," where it is called "*linea aspera*," without, however, any reference to its morphological significance; see Fig. 3885).

J. The vague and unsatisfactory representation of the parts at the porta. This region has yet to be cleared up in respect to the relation of the pial and endymal surfaces; it was his inability to show these relations clearly upon original preparations that led the writer to employ the present figure provisionally.

§ 98. Prop. LXII. *Valvula.*—A caudal portion of the mesocœlian roof retains nearly its primitive tenuity and constitutes a transparent lamina, the valvula, between the gemina and the lingula. Its cephalic part presents some slight corrugations, either a mesal furrow and a pair of lateral ridges, the frenulums (Fig. 4724), or—as in some figures—a mesal ridge as well. The fibres of the trochlearis nerve decussate (perhaps not entirely) in the valvula.

§ 99. Prop. LXIII. The *aqueduct.*—In all mammals the originally spacious mesocœle (Figs. 4690 and 4691) becomes reduced to a slender passage, the aqueduct or *iter a tertio ad quartum ventriculum.* As may be seen from Figs. 4684, 4711, and 4718, it is expanded or trumpet shaped at the cephalic end, and irregular in form at the caudal; the intermediate, longer part varies considerably in different individuals, being sometimes nearly cylindrical, but usually a transection presents points in two, three, or four directions, lateral, ventral, dorsal; the departures from the cylindrical shape are more frequent and distinct in the postgeminal and valvular portion (see Figs. 4711, 4724, and 4725), and may be regarded as vestiges or suggestions of the potentially tripartite condi-

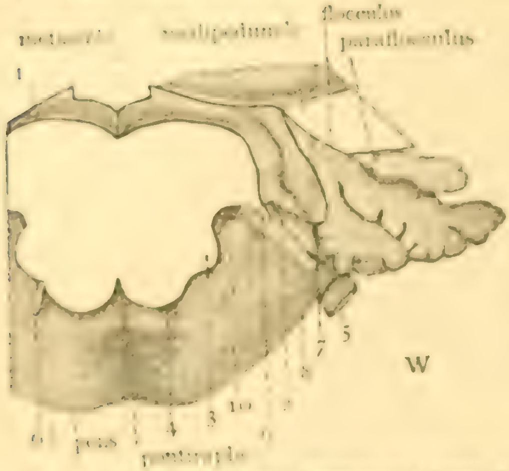

Fig. 4722.—[illegible]

[illegible]

tion which is actually present with birds and frogs (Figs. 4700 and 4701).

§ 100. Prop. LXIV. *Lemniscus and brachia.*—The lateral slope of the mesencephal presents three megascopic features, the lemniscus, postbrachium, and prebrachium, shown in Fig. 4724; in the former the fibres run approximately cephalo-dorsad, in the latter obliquely dorso-ventrad;

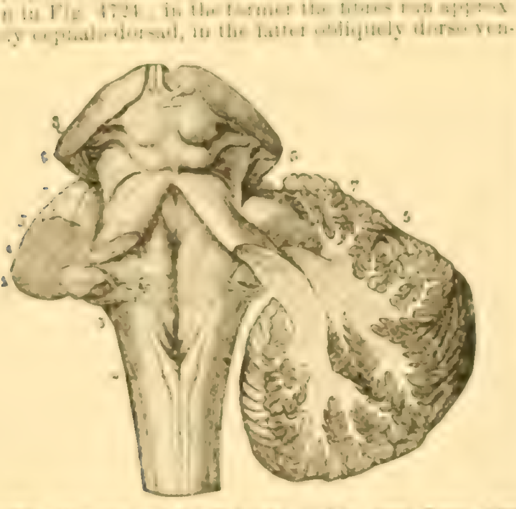

Fig. 4721.—Transection of the Pedunculus, × 1.5. From Quain, after [illegible]

[illegible]

their course and connections are considered in the following article, as is also the extent of the [illegible] called [illegible]. The lemniscus and its connections have been discussed at considerable length by Spitzka in the New York *Medical Record*, xxvi., 393, October 11, 18, 25, and November 1, 1884.

§ 101. Prop. LXV. *[illegible]*.—This is the least

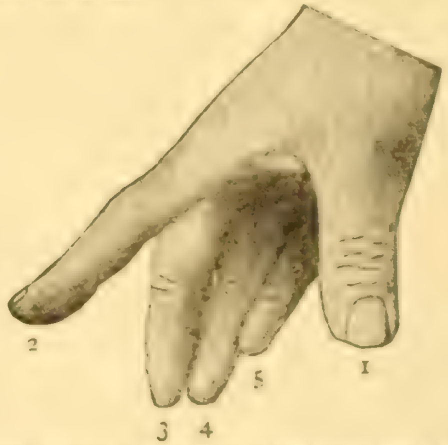

Fig. 4722.—Illustration of the Direction and Relative Size of the [illegible] by the Digits of a Right Hand. [illegible]

modified of all portions of the encephalic "central tubular gray"; its approximate extent at the level of the valvula is indicated by the [illegible] outline.

§ 102. Prop. LXVI. *The crura (crura cerebri).*—Excepting the parts already named, the mesencephal consists

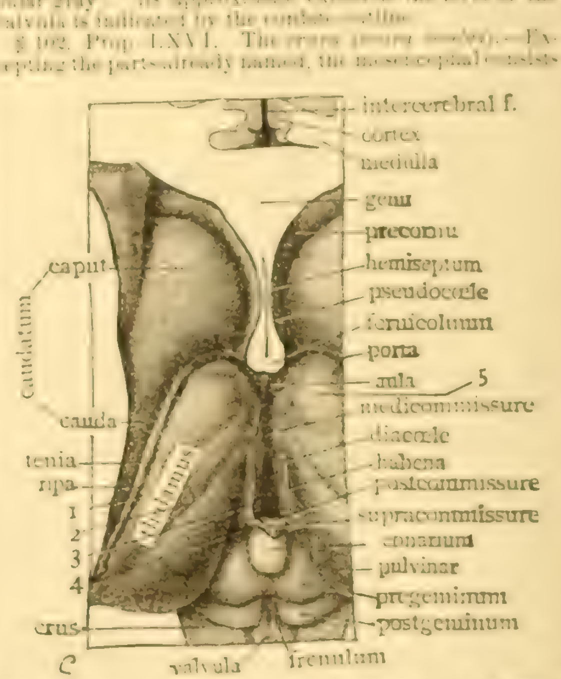

Fig. 4723.—Dorsal Surfaces of the Caudatum, Thalamus, and Mesencephal. [illegible]

[illegible]

mainly of a pair of fibrous masses (Figs. 4689 and 4712) containing the [illegible] motor and sensory conductors between the prosencephal and the metepencephal, thus between the body and the organ of mind. Each crus consists of two regions, a ventral, the crusta, and a dorsal, the tegmentum: Figs. 4724 and 4728.

§ 103. Prop. LXVII. *Intercalatum* (*substantia nigra, locus niger*).—A transection through the crus at almost any level reveals a dark mass (Figs. 4725 and 4728) of crescentic outline, approximately dividing the section into a ventral third and a dorsal two-thirds. Its lateral and mesal borders correspond to the furrows called *sulcus lateralis and s. oculo-motorius.* The name commonly employed refers to the distinctly dark color (due to pigment in the cells) of the mass in man and some apes; but the absence of color in other mammals has led Spitzka to propose (letter to the writer, December 28, 1887), a name referring to its more constant character of intercalation between the ventral crusta and the dorsal tegmentum.

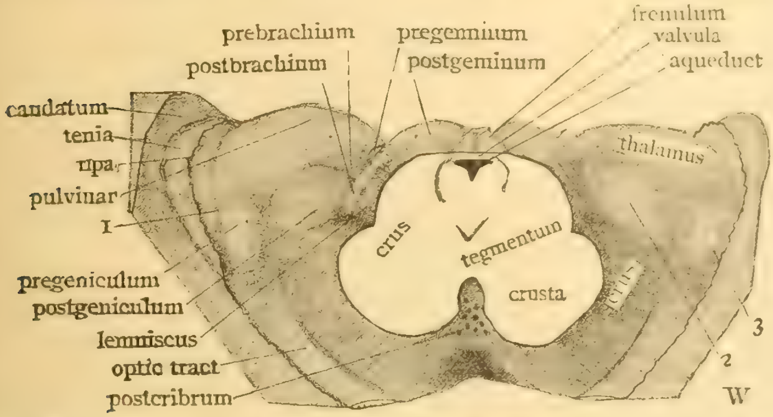

Fig. 4724.—Caudal Aspect of the Mesencephal and Part of the Diencephal. 2360; × 1.5. 1, Tenial sulcus; 2, right postgeniculum; 3, right pregeniculum

Preparation.—A well-hardened, alcoholic, adult brain was transected just cephalad of the pons, at a level indicated nearly by the line from *crus* in Fig. 4723. A block containing the thalami and adjacent parts was then cut out by incisions in various directions, the fornix peeled off, and the velum and other parts of the pia removed; the ink lines near the sides marked *ripa* indicate the lines along which the lateral margins of the velum, the paraplexuses, were torn away.

Defects.—More should have been left at the sides and ventrad. On the left, the roughly indicated curved line just laterad of the tenia was due to inadvertence, and may be disregarded. On the caudal, cut surface the heart-shaped outline was intended to indicate approximately the form of the mesocœlian entocinerea, the aqueductal "central tubular gray," but it is incomplete and perhaps not quite accurate. The intercalatum showed very faintly in the preparation and is omitted, but its location may be seen from Figs. 4725 and 4728.

§ 104. Points illustrated upon Fig. 4724.—A. Segmental overlapping. The thalami and geniculums project caudad beyond the intersegmental line, and the caudatum is here directly laterad of the thalamus instead of cephalad; consequently a transection through the pregeminum would divide not only the mesencephal but also both the diencephal and the prosencephal.

B. The caudal extension of the thalamus as a rounded eminence, the pulvinar on which, at the right, the word *thalamus* is placed.

C. The existence of two other eminences on this aspect of the diencephal, the postgeniculum, mesad and more distinct, and the pregeniculum, laterad and less distinct. With lower mammals, where the general mass of the thalamus is less developed than in man, the pregeniculum is not only still less prominent, but also decidedly cephalad, so that the prefixes *pre* and *post* are much more nearly appropriate.

D. The continuity of the optic tract with both the geniculums, more obviously with the pregeniculum.

E. The nearly complete concealment of the pregeminum, in this view of the parts, by the postgeminum; the former is seen at the left to project slightly.

F. The location and forms of the postbrachium and prebrachium; the former is between the two geminums, the latter just cephalad of the pregeminum; as they pass ventrad they embrace, as it were, the postgeniculum.

G. The location of the lemniscus, just caudad of the postbrachium.

H. The T-shaped section of the aqueduct, the reduced representative of the mesocœle.

I. The thinness of the mesocœlian roof, here constituted by the valvula, with a mesal furrow and lateral ridges, the frenulums.

J. The relatively extreme thickness of the mesocœlian floor, constituted by the crura.

K. The division of each crus into a ventral crusta and a dorsal tegmentum, the boundary between these two regions being defined partly by the lateral furrow, opposite the word crus, on the left, and partly by a pigmented tract, the intercalatum, not here seen, but shown in Figs. 4725 and 4728.

L. The deep ventral depression between the crura, constituting an intercrural area.

M. The presence at the cephalic end of this area of several rather large foramina for the transmission of arterial branches, whence this part is called postcribrum ("posterior perforated space").

N. The trefoil outline of the mesencephalic transection due to the ventrimesal and the two lateral depressions.

O. The obviously and unquestionably pial and ectocœlian character of all the natural mesocœlian surfaces.

P. The equally unquestionable continuity of these surfaces over the geniculums to the pulvinar.

Q. The absence of anything like a ripa on the visible surface of the thalamus until we reach the sharp and irregular line so marked at the left.

R. The endymal and ectocœlian character of the slender natural surface of the caudatum.

S. The continuation of this endymal surface upon the visible length of the tenia.

T. The significance of the ripa as not only a boundary between contiguous pial and endymal surfaces, but as indicating where the margin of the paraplexus or some membranous continuation of it has been torn away.

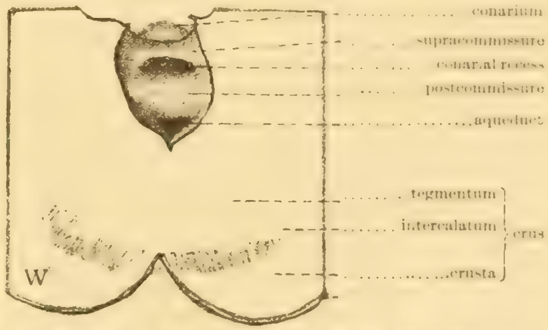

Fig. 4725.—The Postcommissure and Adjacent Parts. 2239; × 1.5.

Preparation.—The diencephal was transected just caudad of the medicommissure, and the cephalic aspect of the caudal part sliced down to near the level of the postcommissure; the diatela was torn away to admit more light. The figure should be compared with the mesal sections (Figs. 4684 and 4711), and with the dorsal aspect of the region (Figs. 4723 and 4728).

§ 105. Prop. LXVIII. The *postcommissure.*—The cephalic margin of the mesocœlian roof is of moderate thickness, and curved dorsad so sharply as to present a cephalic convexity (Fig. 4725) and a caudal concavity (Figs. 4684, 4711). It is probably not a true commissure but a decussation (Quain, ii., 321). Perhaps it belongs to the diencephal, or is *intersegmental* (Osborn, *American Naturalist*, October, 1887, p. 940).

§ 106. Points illustrated by Fig. 4725.—A. The appearance of the postcommissure as a cylinder; see, however, [illegible] and for the [illegible] figured by Dalton.

B. The considerable size of the medicommissure; although a large interthalamic [illegible] be apparently [illegible], it is larger than the [illegible] of the [illegible] in this specimen.

C. The existence of the supracommissure (commissura habenarum).

D. The relative position of these parts. In a less-modified condition of things the two commissures and the conarium should all lie nearly in one plane; but the presence of the supracommissural [illegible] has made the long axis of the conarium cephalo-caudal instead of dorso-ventral, and left the two commissures and the two callosa in a dorso-ventral series instead of a cephalo-caudal.

§ 107. DIENCEPHAL.—Synonyms: Diencephalon, deutencephalon, thalamencephalon, zwischenhirn, interbrain. Tabular arrangement of parts. Chief parts: thalami. Cavity: diacoele. Floor: tuber and diaterma. Sides: thalami. Roof: diatela (especially the velum). Plexus: diaplexus. Commissures and decussations: medicommissure, supracommissure, chiasma. Local expansions: albicantia, pregeniculum and postgeniculum. Perforated areas: preperforatum and postperforatum. Local elevations: taenia. Local depressions: trigonum habenae, ventral, and thalamic sulci. Local depression: sulcus Monroi. Appendages: conarium, hypophysis.

§ 108. Prop. LXIX. With the adult of man and all other mammals the primitively thin sides of the diencephal are greatly thickened and become the thalami, with the geniculums (pre- and post-) as latero-caudal elevations. The relations of the diencephal to the entire brain are well indicated in the young rabbit (Fig. 4694).

§ 109. Prop. LXX. In marked contrast with the massive sides the diencephalic roof is, for the most part, very thin, consisting apparently of the endyma only, closely attached to the ventral or diencephalic layer of the velum, from which are developed the parallel diaplexuses (Figs. 4690 and 4751) dependent at either side. Cephalad, the diatela is continuous with the auliatela or perhaps directly with the fornix dorsad of the aula and porta; caudad, it extends for some distance beyond the proper diencephalic boundary, is reflected ventrad upon the dorsal (properly cephalic) aspect of the conarium, and is then continuous with the supracommissure, and the conarium itself (Fig. 4711). The conarium and hypophysis are considered together in § 116.

§ 110. Prop. LXXI. The diencephalic floor is various in direction and composition. Beginning with the mesencephalic floor, the crura (Fig. 4711), there is a marked decrease in thickness in the region of the postcribrum (which may really be common to the two segments) as well as a deflection of the floor ventrad; the albicantia (Figs. 4689, 4711, and 4778) constitute lateral thickenings, and then the floor is reduced to an attenuated lamina, continuous with the valvula; this, with the shorter, the part just cephalad of the intervening and dependent hypophysis, constitute the tuber (tuber cinereum) and infundibulum. The fusion of the stems of the primitive optic vesicles to form the chiasma, and the fusion of this with the otherwise thin diencephalic floor, confers upon the latter in this region considerable thickness and firmness; but this part is again succeeded by the attenuated terma (Figs. 4711 and 4726), or rather the diaterma, in continuation from the preterma dorsad of the precommissure. Although the diaterma has a nearly dorso-ventral direction, it should properly be regarded as part of the floor, since the aula, the mesal division of the prosocoele, is morphologically cephalad of the diacoele, although actually more nearly dorsal.

§ 111. Points Illustrated by Fig. 4726.—A. The existence and completeness of the terma (lamina terminalis or l. cinerea), constituting the cephalic boundary of the mesal encephalic cavities; in the embryo it is actually the most cephalic part of the brain, but is later concealed by the projecting hemicerebrums.

B. The continuity of the terma with the chiasma, leading to the rupture of the former during the removal of the brain unless the optic nerves are early divided.

C. The extreme thinness and delicacy of the terma, which cannot be represented adequately in such a view, and is not fairly indicated in the outlines.

D. The existence of a somewhat thicker extension of the terma at each side, forming the cephalic boundary of the optic recess.

E. The pair of slightly raised bands, commonly termed the "peduncles of the corpus callosum."

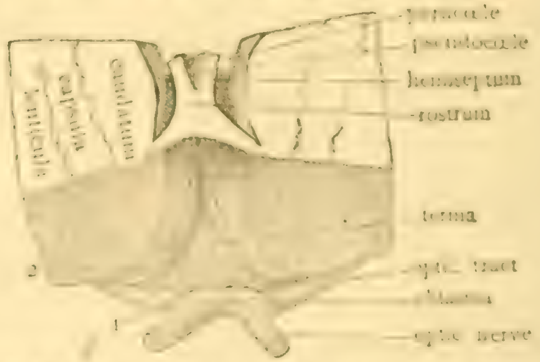

FIG. 4726.—Cephalic Aspect of the Terma ("lamina terminalis") and Adjacent Parts of a Young Adult. (× 1 [illegible].)

Preparation.—The brain was exposed by removing the skull with [illegible] and scissors so as to avoid injuring the terma. The optic nerves were divided close to their foramina of exit. After hardening in alcohol the parts adjacent to the terma were removed [illegible]

F. The convexity of the entocoelian surface of the caudatum (see also Fig. 4725).

G. The relation of the callosal rostrum to the hemiseptums, the lateral halves of the septum lucidum.

H. The somewhat unusual thickness of the hemiseptums in this specimen.

§ 112. Prop. LXXII. The mesal surface of the thalamus is divided into a dorsal and a ventral area by a slight furrow, sometimes hardly perceptible, the sulcus ("sulcus of Monro") (Fig. 4711), leading from the porta to the cephalic orifice of the mesocoele, and presenting a ventral convexity. At the dorsal margin of this surface is the habena, a slight ridge, with a dorsal convexity, extending from the porta to the supracommissure, which unites it with its opposite. Along the dorsal side of the habena is the habenal sulcus, and the two represent nearly the line of reflection of the endyma from the mesal surface of the thalamus upon the roof of the diacoele (see Figs. 4684, 4711, 4725, and 4751).

§ 113. Prop. LXXIII. Medicommissure.—Primarily separate, the opposed mesal surfaces of the thalami unite at about the fifth month of gestation according to Mihalkovics, giving rise to what is commonly called the "middle commissure" (Figs. 4684, 4711, 4725, and 4726). It is in a direct line between the porta and the aqueduct, considerably nearer the former, and just dorsad of the sulcus. The shorter, dorso-ventral, diameter is 4.5 mm., the longer, cephalo-caudal, 6-7. Sometimes it is said to be in two parts, one above the other; it is absent, according to Wenzel, ten times out of sixty-six. It consists mainly of cells (with, according to W. Krause, some fibres) and is so soft as to be commonly torn during the removal or manipulation of the brain. It is relatively larger in most other mammals; the functions are experimentally unknown, but in a man (Mall) and a cat (the writer, article Malformations of the Brain) lacking the callosum, it was larger than usual.

§ 114. Points Illustrated by Fig. 4727.—A. The size, form, and connections of the medicommissure; it is relatively smaller than in the cat, and slightly constricted about its middle; if isolated it would have the form of a pulley-wheel with a shallow groove.

B. The relations of the mesal aula to the portas and to the diacœle; of the space commonly called "third ventricle," the strictly interthalamic portion only constitutes the diacœle, while that part which intervenes between the fornix and a line drawn between the two projecting points (1) of the thalami must be regarded as the mesal division of the prosocœle; it and the two portas are sometimes embraced within the single term *Foramen of Monro,* but this name more properly applies to each porta; see the writer's article in *Boston Medical and Surgical Journal,* August 12, 1880.

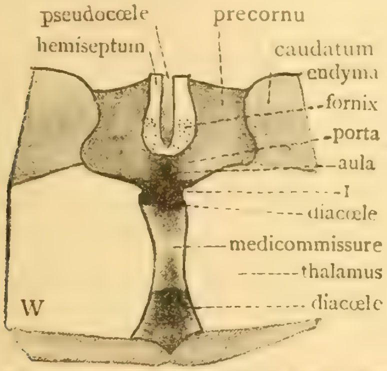

FIG. 4727.—The Medicommissure and Adjacent Parts. 2032; × 1.3. (Compare Fig. 4723, where some of the same parts are shown on a smaller scale.)

Preparation.—The brain was removed with care so as not to tear the medicommissure, and alcohol was injected *per luram* so as to harden the parietes and keep them apart. The prefrontal lobes were then removed, thus opening the precornua and exposing the caudatums; with these as guides the block containing the medicommissure was safely isolated; the thalami are cut away almost to the level of the commissure. This is the only specimen in the museum with this easily injured part complete.

C. The thinness of the lamina uniting the two halves (columns) of the fornix. This lamina must be regarded as the primitive prosocœlian terma as high as the dorsal limits of the porta, and may, therefore, be called the *prosoterma* (see a figure in the article Malformations of the Brain).

§ 115. Prop. LXXIV. The pregeniculum and postgeniculum are represented in Figs. 4723 and 4724, and described in connection therewith; the optic tract and the chiasma are shown in Figs. 4689 and 4726, and considered in connection with the optic nerves in the article, Cranial Nerves, Vol. II.

§ 116. Prop. LXXV. *Conarium* and *hypophysis.*—Excepting the lancelet (*Branchiostoma*) every known vertebrate has both these apparently functionless organs. This constancy alone would justify us in regarding them with interest, but as described under Development of the Brain, Vol. I., p. 638, the hypophysis has a double constitution and origin, from the brain (posthypophysis), and from the enteron (prehypophysis), while the number of forms in which has been traced a connection between the conarium and a rudimentary mesal eye is so great as apparently to warrant the view that it is the remnant of a primitive mesal organ of vision. Herdman thinks the hypophysis also may have been an ancestral sense organ (*American Naturalist,* 1888, p. 1127), while Max Flesch holds that the mammalian conarium is connected with the temperature apparatus.

§ 117. Prop. LXXVI. Peculiar topographical relations of the conarium.—Although directly connected with the thalami, the conarium leans caudad so as to rest upon the pregeminum; the cephalic aspect of the cerebellum rests upon the postgeminum and abuts against the conarium; finally the callosum, a cerebral commissure, has its splenial curvature upon the conarium. Between all these parts, of course, there are membranes and vessels, but if they are disregarded, the [illegible] of one segment, the diencephal, may be described as encompassed by three others, the mesencephal, the epencephal, and the prosencephal. With a brain hardened in its natural shape, a disk 2 ctm. in diameter will cover parts of all four encephalic segments; see Figs. 4684 and 4711.

§ 118. Prop. LXXVII. *Acervulus.*—The adult conarium frequently has imbedded in follicular cavities calcareous particles known by the above name, and as "brain-sand;" in the brain shown in Fig. 4711, it was so abundant as to leave a considerable cavity when removed, as shown in the *New York Medical Journal,* March 21, 1885.

§ 119. Points illustrated by Fig. 4728.—A. The form, direction, and complete separation of the albicantia; they are usually represented (as in Figs. 4689 and 4712) as hemispherical elevations; here they are seen to be elliptical in outline, their longer axes converging caudad, and the caudal ends overhanging the posteribrum; in the cat and in mammals generally the albicantial sulcus is a shallow depression or wholly absent.

B. That the hypophysis is wider than long, and consists of two parts, conveniently called *prehypophysis* and *posthypophysis*; the latter is the smaller and partly as it were let into an emargination of the former.

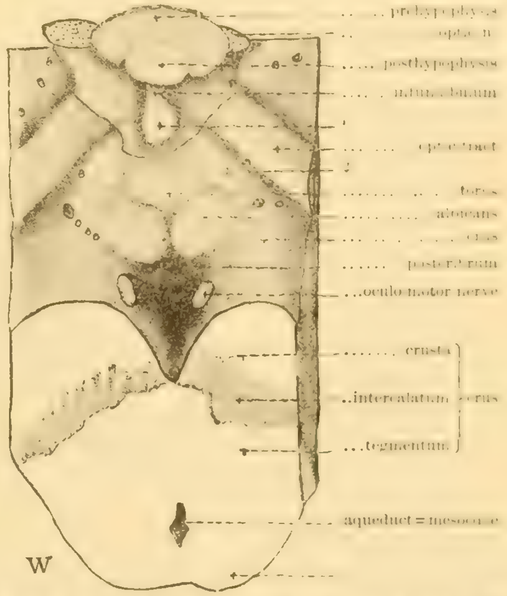

FIG. 4728.—The Torus (*tuber cinereum*) and Adjoining Parts. 706; × 1.5. (The same region is shown in Figs. 4689 and 4712, upon a smaller scale.) 1, Expanded proximal end of the infundibulum, covering the lura, which is exposed in Fig. 4689; 2, a slight elevation between the torus and the optic tract. The irregular line across the torus and optic tracts represents the cut or torn edge of the pia, which adheres quite firmly to the chiasma. The black spots represent the foramina in the posteribrum and elsewhere through which vessels passed; the triangular region laterad of the chiasma is a part of the precribrum ("anterior perforated space").

Preparation.—The brain was removed with great care, the hypophysis being extricated from its fossa by dividing the dural folds in several directions with the sharp point of a scalpel, and then introducing the blunt-pointed syringotome. This is the only preparation in the University museum to which the hypophysis remains attached. Its [illegible] by the movements of the alcohol during hardening was prevented by passing a fine entomological pin through it and the chiasma, which is very firm.

Defects. The natural surfaces of the crura should have presented a more fibrous appearance (somewhat as in Fig. 4712), and another preservative than alcohol would have differentiated the colors on the cut surface. The albicantia have perhaps the appearance of overlapping the posteribrum too far, but this is more nearly correct than the usual representation, as for example, in Figs. 4689 and 4712. The left intercalatum should be shown more nearly like the right.

C. The expanded base of the infundibulum (1).

D. The raised, unnamed area (2) at either side of the torus.

E. The demarcation of the crura from the tegmentum by the intercalatum.

F. The slight, angular extremities of the [illegible] (appendix), which otherwise is almost circular in outline.

§ 120. PROSENCEPHALON.—Synonyms: Prosencephalon, fore-brain, secondary fore-brain. Tabular Arrangement of Parts: Chief parts: hemicerebrums. Cavity: prosocœle (including the aula and the following in pairs: porta, paracœle, cella, precornu, medicornu, and postcornu). Floor: [illegible]. Sides: caudatum, hemiseptum. Roof: [illegible], callosum. Commissures and decussations: callosum, precommissure, fornicommissure. Enlargements: callosum, etc. Intercalatum, porta. Detached [illegible], lentiform. Cinerea: [illegible] elevations: [illegible], hippocampus, calcar, occipital eminence, collateral eminence, [illegible] eminence of the [illegible]. Total elevations: gyres, insula. Total depressions: fissures. False cavity: Pseudocœle. Plexuses: proplexus (including auliplexus, portiplexus, paraplexus). Line of plexal intrusion: rima. Ripatiæ parts: tænia, fimbria. Atrophied parts: prosoterma, hemiseptum, pars.

§ 121. Prop. LXXVIII. The prosencephal comprises the two lateral masses, hemicerebrums, the mesal parts by which they are connected, and a pair of olfactory bulbs, with their crura.

122. Prop. LXXIX. The olfactory bulbs with their crura (Figs. 4684, 4689, and 4718), at and after birth, are relatively so small as to be commonly regarded as insignificant appendages of the cerebrum, or even as mere nerves; but their constancy throughout the vertebrate branch (even *Amphioxus* is said to have a single, unsymmetrical olfactory lobe), their great size among many lower members of the branch and even with many mammals, their mode of development, their direct connection with the hemicerebrums (Figs. 4708 and 4782), their relation with the precommissure in most mammals, and the persistence with all mammals excepting man and perhaps the apes of a cavity, the rhinocœle, continuous with the paracœle, justify their recognition as of considerable morphological significance. As intimated in § 15, it is not impossible that they may prove to be primary, and the "cerebral hemispheres" secondary. For the present, however, and in this part of this article, it can only be added that from the slightly enlarged bulbs are given off the true olfactory nerves to the nasal mucosa; see article Cranial Nerves, Vol. II.

§ 122. Points illustrated by Fig. 4766.—A. The existence of the paracœle, medicornu, precornu, paraplexus, and porta in the cat substantially as in man.

B. The absence of a postcornu.

C. The larger relative size of the precornu.

D. The continuation of the precornu through the olfactory crus into the bulb, as a perfect rhinocœle slightly enlarged at the extremity, as in most mammals other than man.

E. The bifid condition of the medicornu is exceptional; it commonly ends roundly or with a single blunt point.

§ 123. Prop. LXXX. Primarily the cerebrum is a pair of lateral extensions of a small mesal rudiment, the first (cephalic or "anterior") encephalic vesicle; this forms their only bond of union with one another and with the other segments; their walls are thin and vary little in thickness or composition. Secondarily, the two hemicerebrums are closely connected by the callosum and other commissures; between the cerebrum and the crura (and thus the oblongata, the myel, and indirectly the entire body) are developed extensive fibrous communications, the capsules or "internal capsules;" the parietes are for the most part extraordinarily thickened, the most notable, and physiologically the most important of these increments constituting what are commonly called the "corpora striata" from the appearance presented on sections of alternating stripes of alba and cinerea. Each striatum, however, is now recognized as composed of an entocelian ("intraventricular") portion, the caudatum, and an ectocelian ("extraventricular") portion, the lentiform ("lenticular" or "lentiform nucleus"), separated by the capsula already mentioned (see Figs. 4722, 4726, 4751 and 4772).

§ 125. Prop. LXXXI. The striatum.—With all Reptiles, Birds and Mammals, and at a very early period (Figs. 4692, 4709, 4710, 4725, 4726, 4727, 4746 and 4768), the lateral wall and floor of the paracœle present a more or

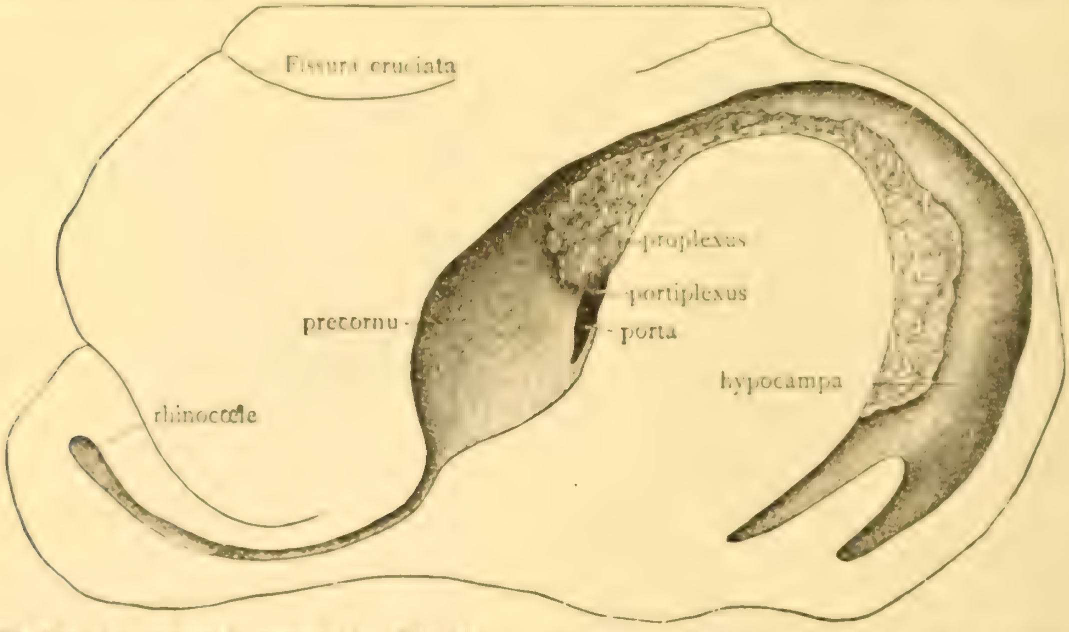

FIG. 4766.—The Left Paracœle and Rhinocœle of a Cat. [illegible]

[illegible]

less distinct elevation; in man, and some other mammals the form is such as to suggest the application of *caput* to the cephalic (precornual) portion, and *cauda* to the tapering continuation along the medicornu, thus of *caudatum* to the entire mass. It is a modification and differentiation of the entocinerea, and may perhaps be regarded as the colliculus collocated with the Sylvian fissure (Fig. 4709).

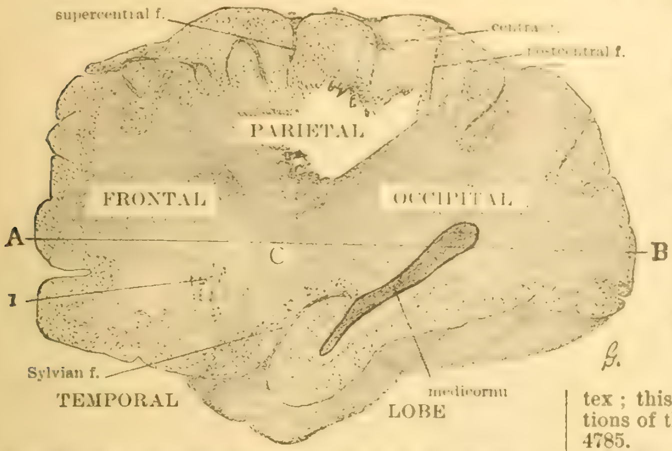

FIG. 4730.—The Right Hemicerebrum of a Male Negro, Dissected to Show the Location of the Capsula. 2397; × .5.

Preparation.—The fresh hemicerebrum was supported on a bed of cotton on its lateral surface, a large, thin-bladed knife, kept wet with alcohol, was used to remove thin slices from the mesal aspect until a distinct patch of alba was encountered opposite the porta; from this as a centre (C) oblique incisions were made in three directions, cephalad, caudad, and dorsad, thus removing thin wedge-shaped slices until, excepting the cortex, cinerea was visible only in scattered patches (1); the preparation was photographed and then divided along the line A B, and the dorsal surface of the ventral part photographed (see Fig. 4731).

Defects.—The brain was far from fresh and so soft that the sections were made with difficulty and certain important points as to the distribution of the alba and cinerea about the medicornu could not be determined. A more satisfactory preparation could be made by first dividing the entire hemicerebrum along the line A B, and then removing the wedge-shaped slices, after which the dorsal and ventral parts could be joined if desired. All this could also be accomplished more easily upon a brain so preserved as to indicate the cinerea and alba more perfectly than alcoholic specimens.

§ 126. Prop. LXXXII. The *lenticula.*—Between the caudatum and the cortex the greatly thickened hemicerebral wall presents (*a*) the medullary lamina called *capsula* (§ 127); (*b*) next the cortex, a sub-circular disk of cinerea, the *claustrum* (better shown in Fig. 4795); and (*c*) the *lenticula*, consisting of three zones, all more or less striated, the ental the smallest, and the ectal, also called *putamen*, the largest (Figs. 4731 and 4732). The lenticula, like the claustrum, may be a dismemberment of the cortex. This entire region, from caudatum to operculums, is of great morphological as well as physiological interest and should be studied in the other mammals.

§ 127. Prop. LXXXIII. *Capsula* and *corona.*—As already stated (§ 124) the capsula or "internal capsule" is the thick layer of fibres between the caudatum and thalamus mesad and the lenticula laterad; it is continuous with the crura caudad, and expands in the substance of the cerebral alba in such a way as to be called there *corona* (*radiata*). The histological and physiological aspects of the capsula and corona are considered in the following article, and in Vol. I.; here an attempt will be made only to indicate their topographical relations by explanations of the accompanying figures (4730, 4731, and 4732).

§ 128. Points illustrated upon Fig. 4730.—A. The existence of a stratum of alba, white, medullary or fibrous nervous tissue, the capsula, between the lenticula laterad and the caudatum and thalamus respectively meso-cephalad and meso-caudad.

B. The completeness of this albal interval between the three cinereal masses, excepting in the cephalo-ventral region (1), where the amygdala, caudatum, and lenticula are loosely connected.

§ 129.—Points illustrated upon Fig. 4731.—A. The general relations of the alba (medulla) to the ectocinerea (cortex).

B. The locations of the two great masses of entocinerea (central tubular gray), the caudatum and the thalamus.

C. The intermediate position of the lenticula, as a blunt wedge-shaped mass between the caudatum and thalamus.

D. The position of the capsula ("internal capsule") as a stratum of alba between the lateral lenticula and the other two masses, and constituting a fibrous path for motor and sensory conduction between the cortex and the crura.

E. The existence of two zones in the lenticula, the more lateral being distinguished as *putamen*; a third would have appeared at a level farther ventrad (Fig. 4732).

F. The existence of a thin, cinereal lamina ectad of the lenticula, between it and the cortex; this is the claustrum; it and the cortical corrugations of this region are shown upon a larger scale in Fig. 4785.

§ 130. Points illustrated upon Fig. 4732.—A. the existence and relative positions of four important masses of connecting fibres, the *callosum*, *forniculumns*, *precommissure*, and *chiasma*, differing from one another in either their direction or their appearance upon this section. The most ventral, the chiasma, is mainly a decussation (as described in Vol. II., article Cranial Nerves. The next, precommissure, is a true commissure, connecting corresponding regions of the temporal (and frontal ?) lobes; at the meson it is seen as a raised transverse band, but laterad, on account of its deflection caudad, it is divided

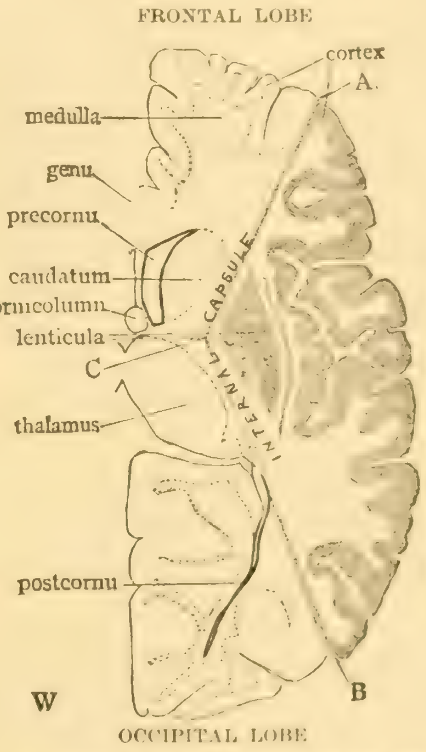

FIG. 4731.—Longisection of the Right Hemicerebrum (Fig. 4730) at the Level of the Aula. × .05; from nature 2397 and from Gray.

Preparation.—See Fig. 4730. The mesal outlines of the removed frontal and occipital regions were adapted from Gray. The plane of section corresponds nearly with the direction of the dotted line from *aula* on Fig. 4732.

obliquely, and appears as an elliptical [illegible] area. The two hemicerebrums have at this level a nearly dorso-ventral direction, appearing as equal bands just dorsal of the precommissure (the band forms the [illegible] most clearly upon the right), but they are curved in such a way as to be divided obliquely in two places—one at the level of the precommissure and the other about one centimetre [illegible]. Finally the callosum, a true commissure, uniting corresponding regions of the cerebrum, is divided in the direction of its fibres.

B. The general relations of parts and cavities at this important level. Two segments are represented—the diencephal (thalamus, chiasma, etc.) and prosencephal (the remainder) and much the larger part. Of the cavities, the mesal space between the chiasma and precommissure is the cephalic part of the diacoele, the dorsal portion being the optic recess. The prosocoele is represented by the aula, the mesal space dorsal of

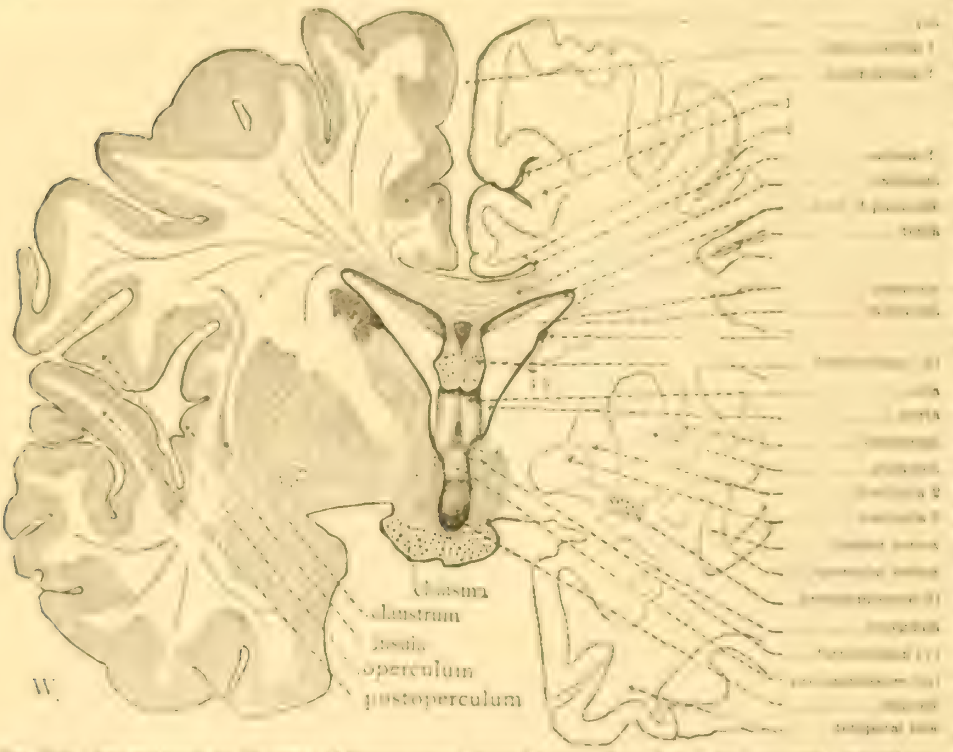

FIG. [illegible].—[illegible]

and including the precommissure; by the considerable lateral cavities, *paracoeles*; and by the intervening *portas*. All these are true encephalic cavities, but the dark, triangular area still farther dorsad is the pseudocoele, a space included as a result of secondary changes (§ 62 E and Fig. 4765). Three kinds of surfaces are included, viz.: entocoelian, lined by endyma; ectocoelian, covered by pia; and pseudocoelian, with no distinct membrane. There is cinerea (cortex, caudatum and thalamus), and what may, for the sake of a general term, be called [illegible] the lenticula and the claustrum, probably [illegible] of the [illegible].

C. The extension of the hemicerebrum nearly equally in three directions from the place of its morphological center, the porta; were this brain not somewhat depressed by its own weight, the width and height would be nearly the same.

D. The thickness of most of the parietes as compared with the earlier fetal conditions shown in Figs. 4708 and 4760, the hemicerebrums and the terma, however, have retained their tenuity in great degree.

E. The absence of the fornicula, which was seen in a young brain (Fig. 4758), and is constant in the cat (Fig. 4760); whether it is replaced or merely obscured in the human adult is not known.

F. The overlapping of the precommissure at the sides of the cephalic part of the caudatum upon the thalamus.

G. The relations of the several layers of alba and cinerea between the thalamus and the lateral surface of the cerebrum. The capsula (?) has an oblique direction, dorso-laterad, between the thalamus and caudatum, and the lenticula (see Fig. 4760). The lenticula itself comprises three more or less distinct segments, each extending farther dorsad than the one mesad of it; and presents the alternating lines of white and gray which led to the application of *striatum* to the united lenticula and caudatum. The thin lamina of cinerea between the putamen, the most lateral division of the lenticula, and the insular cortex is the claustrum; and the alba between it and the lenticula is commonly, but inappropriately, called the "external capsule."

H. The relations of the insula to the parts just named, and to the several plications which constitute the operculum (see Fig. 4696).

I. The relation of the cinereal mass called *amygdala* to a fissure opposite the [illegible] of postoperculum, which has thence been named the amygdaline fissure (Figs. 4766 and 4770).

§ 131. Prop. LXXXIV. The *precommissure* (anterior commissure).—In all medisections of the brain (Figs. 4684, 4711, 4738, and 4766) nearly dorsal of the chiasma is to be seen a marked thickening of the parietes, which remain thin ventrad (chiasma) and dorsad (precommissure); this thickening is the precommissure, a compact bundle of nerve fibres, transverse laterad with a slight ventral and caudal deflection, into the temporal lobes of the cerebrum (Figs. 4772 and 4743). With most other mammals it divides, at a little distance from the meson, into two portions, a temporal, alone perhaps represented in man, and an olfactory, which passes cephalad to the olfactory bulbs, with, especially in the lower mammals, a subdivision to the frontal lobes. This olfactory portion is probably primary and of greater morphological importance than the other.

§ 132. Prop. LXXXV. Besides the precommissure, a medisection displays two extensive lines of cut surface (Figs. 4684, 4698, 4711, and 4766), indicating that there was a continuity of the apposed mesal surfaces of the two hemicerebrums. Of these the dorsal, more extensive and more substantial, is the *callosum* (Figs. 4732, 4733, 4743, and 4744); the ventral is the *fornicommissure* or mesal part of the fornix (Figs. 4734 and 4737). The development of these parts is considered in Vol. I. 539, and the writer of that article has since published important papers respecting them and the precommissure. Here space will permit of only brief descriptions of the adult conditions with special reference to the points shown in the figures.

§ 133. Prop. LXXXVI. The *callosum.*—When the fresh hemicerebrums are divaricated, as in Fig 4733, the bottom of the intercerebral fissure is seen to be formed by a white mass which unites them for more than the middle third of their length; upon hardened brains this, the callosum (*corpus callosum, trabs cerebri*, etc.), is easily determined to be fibrous, and somewhat firm in consistency, and to extend into the hemicerebral masses. At about the middle of its cephalo-caudal extent, the trend of the callosal fibres is almost directly laterad, but at the cephalic and caudal ends, especially the latter, the direction is oblique, giving rise to the conditions known as *preforceps* and *postforceps* (Figs. 4688, 4690, and 4691). The rounded cephalic region of the callosum is called *genu*, and the caudal, *splenium*. As seen in medisections (Figs. 4684, 4711, and 4718), the genu obviously represents a folding of the callosum upon itself, the ventral continuation being the *rostrum*, which, in man and perhaps in apes, is connected with the terma by the thin *copula*. The gentle curve of the genu gives to the cephalic part of the pseudocœle a rounded outline.

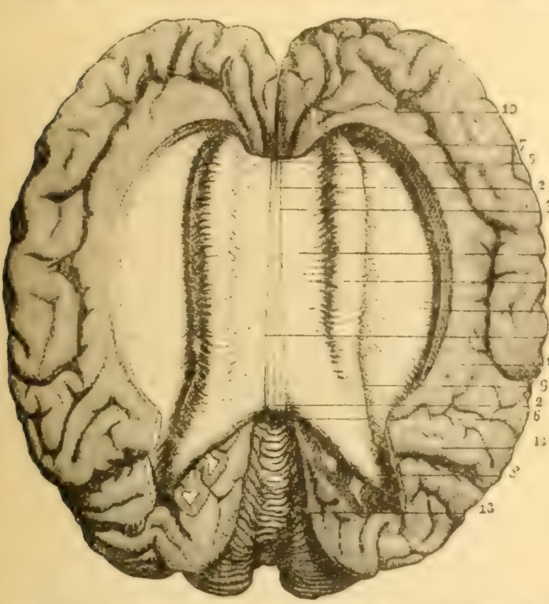

FIG 4733.—The Dorsal Aspect of the Callosum, Exposed by Divaricating the Hemicerebrums. From Quain, after Sappey and Foville; × 0.5. 1, Dorsal surface of the body of the callosum; 2, mesal ridge or raphé; 3, lateral ridges, bounding furrows in which, sometimes at least, are lodged the precerebral arteries; 4, lateral ridge, said to be formed by the arching of the callosum over the paracœle; 5, cephalic curved margin, genu; 6, caudal curved margin, splenium; 7, preforceps, callosal fibres passing cephalad into the frontal lobes; 8, postforceps, fibres entering the occipital lobes; 10, cephalic portion of the callosal gyre, the line crossing the cephalic end of the supercallosal fissure; 11, callosal fissure; 12, caudal part of the callosal gyre, the line crossing the paracentral gyre; 13, cephalic surface of the cerebellum, the number being just caudad of the occipital fissure

Preparation.—While fresh the dorsal portions of the hemicerebrums were separated widely; the curved margin of the callosal gyre ("*gyrus fornicatus*") has been detached and pushed laterad so as to expose more completely the extension of the callosal fibres into the hemicerebrum; caudad this gyre has been divided.

§ 134. Prop. LXXXVII. The *splenium.*—This region of the callosum is much less easy to understand than the genu from the study of normal adult brains, but most of the difficulties are removed or diminished by the study of fœtal and hydrocephalous specimens (Figs. 4734 and 4757). From these it is clear that, like the genu, the splenium represents a flexion of the callosal sheet upon itself so that there is a dorsal lamina, a ventral lamina, and a caudal connecting portion; commonly the dorsal and ventral portions are in close contact, but in hydrocephals (Fig. 4734), as in the fœtus at a certain stage, they are separated by a considerable interval; in these cases the pseudocœle has a greater extent and a somewhat rounded caudal end.

§ 135. Points illustrated upon Fig. 4734.—A. The complete separation of the fornix and callosum as far as the splenium, which is thus a common bond between them, although usually, and perhaps properly, reckoned as a constituent of the callosum only.

B. The concomitant extension of the pseudocœle and of the hemiseptum.

C. The large size of the porta.

D. The wasted appearance of the visible gyres, in contrast with those of Chauncey Wright (Fig. 4779).

§ 136. Points illustrated upon Fig. 4735.—A. The lapping of the cerebrum upon the diencephal, so that the transection of one includes the other.

B. The folding of the pia covering the now apposed dorsal surface of the thalami and the ventral surface of the cerebrum so as to constitute the velum (see Fig. 4751), but since this figure does not represent the lapping of the prosencephal upon the diencephal at the *sides*, or the

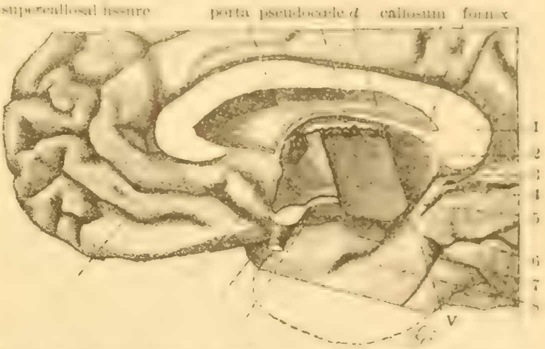

FIG. 4734.—Mesal Aspect of Part of the Left Hemicerebrum of an Adult Hydrocephalus. 747; × 7. The dorso-ventral line *d v*, indicates the transection plane represented in a figure in the article Malformations of the Brain. 1, Splenium; 2, ventral surface of fornix; 3, subsplenial gyres; 4, 5, ?; 6, collateral fissure; 7, uncus; 8, hippocampal fissure. The tip of the temporal lobe, included by the interrupted line just cephalad of *v*, indicates what was removed to expose the parts shown in Fig. 4752.

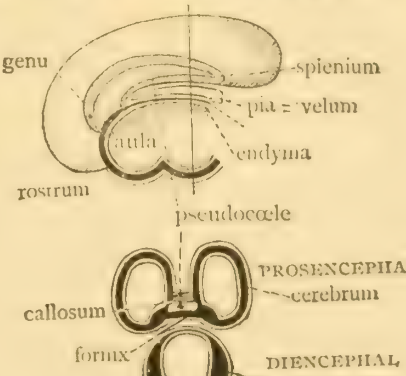

FIG 4735.—Diagrams Illustrating the Relations of the Callosum, Fornix, and Pseudocœle, the Constitution of the Velum, and the Superposition of the Prosencephal. Modified from diagrams published by the writer in the *New York Medical Journal*, February 16, 1884.

Defects.—The aula, the mesal part of the prosocœle, is shown of equal size with the diacœle, and on the same level; this is not the case, so far as the writer is aware, with any vertebrate in which the callosum and fornix attain dimensions such as are indicated in the figure (see Fig. 4766), but so far as concerns the special objects of the figure, the above inconsistency may be ignored. Unlike most of the figures the substantial nervous parietes are represented by the heavy black line, the pia and endyma by lighter ones.

formation of the rima and paraplexus, the pia of the two segments is continued independently around each.

C. The theoretical constitution of the [illegible] tract is (1) the pseudo[illegible], though not always actual, continuation of the [illegible] at the sides; (2) the [illegible]; (3) the [illegible] pia, one or both layers according to the closeness of their adhesion.

D. The relations of the callosum, fornicommissure, and paraplexus: the two former represent two lines of secondary junction between the apposed mesal surfaces of the hemicerebrums; they are coëxtensive at the splenium and [illegible] in front of the cephalic end; the space thus

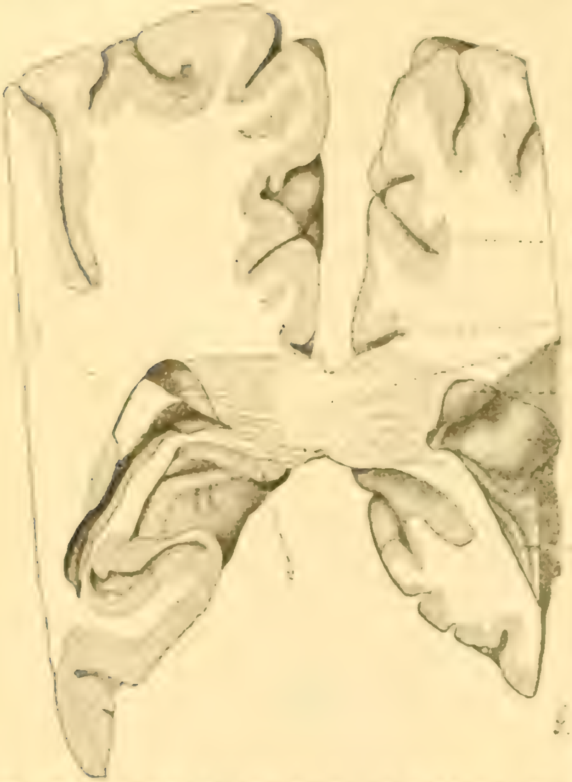

FIG. 4756.—Transection of an Adult Brain Through the Splenium. [illegible]

Preparation.—[illegible] New York Medical Journal [illegible]

Fulcrum.—[illegible]

interrupted, like the lumen of a partition, is the pseudocele or "fifth ventricle." It is really narrow, but the relations are as indicated.

E. The general constitution of the fornix more fully described in § 139.

§ 137. Prop. LXXXVIII. For the most part the callosum extends dorsad of the paraplexus (thus constituting their actual though not primary roof), but the fibres extending obliquely cephalad and caudad from the genu and splenium are parts of the mesal wall of the precornua and postcornua respectively, while those which compose the ventral lamina and the splenium are parts of the paracœlian floors, continuous with the fornix (Figs. 4756 and 4755).

§ 138. Points illustrated by Fig. 4756.—A. The continuity of the splenium with both the floor, roof, and caudo-mesal wall of the postcornua; some of the fibres pass dorsad, some ventrad into the hippocamp, while others, constituting the postforceps, extend caudad into the calcar, dorsocaudad into the occipital eminence, and ventro-caudad into the collateral eminence.

B. The unusual distinctness of the occipital eminence, this being, in fact, the preparation in which it first attracted the writer's attention (see Fig. 4764).

C. The prominence of the calcar; both seen, of course, greatly foreshortened; of the left hippocamp only a segment of the caudal convexity appears in this preparation, with the collateral eminence just beyond (compare Fig. 4750).

§ 139. Prop. LXXXIX. *Fornix* is a collective noun, a comprehensive name applied to a congeries of parts, each of which has its own name, and all of which, with a single exception, may exist in lower vertebrates and in man or other mammals, in certain anomalies, without the formation of the fornix as a whole.

§ 140. Prop. XC. *Fornicolumna.*—In each hemicerebrum there is a bundle of fibres ascending from the albicans and thalamus, passing just caudad of the precommissure, forming the cephalic boundary of the porta, diverging presently from its opposite, pursuing a curved direction along the floor of the medicornu and ending in the temporal lobe; in the mesal region where it is most compact and exposed, this is called an "anterior pillar of the fornix;" herein fornicolumna.*

§ 141. Prop. XCI. *Hippocamp.*—In each hemicerebrum there is a corrugation of the entire thickness of the parietes, resulting in the formation of a total fissure, the hippocampal (§ 204, C) and an entocœlian eminence, or colliculus, the hippocamp, along the medicornu; the hippocamp is thickened also, and intimately associated with the fibres of the fornicolumna already mentioned.

§ 142. Prop. XCII. *Fimbria.*—In each hemicerebrum between the hippocamp, with its corresponding cortex and the rima or line of intrusion of the paraplexus, there is a zone consisting of white fibres, and forming, as it were, a margin for the hippocamp (Figs. 4746, 4752, and 4755). This is the fimbria, corpus fimbriatum, *taenia hippocampi*.

§ 143. Prop. XCIII. The fornicolumna and its caudal curved extension, the hippocamp and the fimbria, are simply portions of the paracœlian parietes, mainly of the paracœlian floor; they are continuous with the mesal wall, lamina septum (Fig. 4751), and thus indirectly with the roof (callosum); excepting at the ventral end, in the tip of the temporal lobe, however, their substantial continuity with the callosum and roots and other portions of the paracœlian parietes is interrupted by the rima. It would be perfectly legitimate, therefore, to designate the irregular, elongated portion of either paracœlian floor, composed of hippocamp, fimbria, and fornicolumn by a special name, *e. g.*, [illegible].

§ 144. Prop. XCIV. *Fornicommissure.*—The parts composing either hemifornix pertain each to its own hemicerebrum, and in brains where the callosum is undeveloped (see article Malformations of the Brain), these have no connection across the meson dorsad of the aula and porta, representing the primitive mesal cavity of the prosencephal. But as the callosum itself is a line of secondary union of apposed mesal surfaces of the hemicerebrums at one level, so at a more ventral level, contiguous cephalad with the primitive precommissure, at each side of which is the fornicolumna, and continuous caudad with the ventral lamina of the splenium, the two hemifornices are united by a lamina of greater or less thickness, the fornicommissure. This is not, at least in man, apparently a true commissure, or even fibrous in structure, and a name like *fornical fusion* might be more appropriate.

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* The application of "pillar" or "column of the fornix" to the [illegible]

§ 145. Prop. XCV. *Septum lucidum.*—Like the fornix, this is composed of two independent parts of the two hemicerebrums (Figs. 4723 and 4735); each half (hemiseptum) is a portion of the mesal wall of the paracœle which has been demarcated from the rest by the formation of the callosum and fornicommissure; the thinness in man is by no means common among other vertebrates, so that the adjective *lucidum* is not only superfluous but inappropriate.

§ 146. Prop. XCVI. *Pseudocœle* ("fifth ventricle").—This is the space between the two apposed halves of the septum (hemiseptums); it was originally merely a part of the intercerebral interval or fissure, but is isolated therefrom, partly in other animals, but completely in man, by the continuity of the callosum with the fornix at the splenium and at the copula (Figs. 4711, 4723, and 4735).

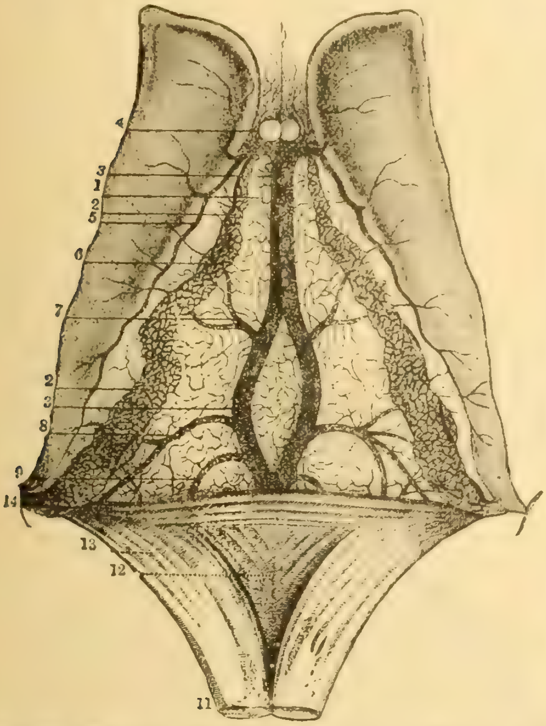

Fig. 4737.—The Velum and Lyra, × 1.5. From Quain, after Sappey and Vicq d'Azyr. 1, The narrower cephalic part of the velum; 2, left paraplexus, the margin of the velum which enters the paracœle as the paraplexus; 3, left velar vein, partly covered by the right; 4, fornicolumns, with small veins said to come from the callosum and septum, the precornual veins; 5, temal vein; 6, medicornual vein; 7, thalamic vein; 8, vein from left medicornu; 9, postcornual vein; 11, body of fornix, transected and reflected; 12, lyra; 13, on the lateral part of the fornix; 14, splenium. (The names here employed for the veins are those adopted by the writer of the article Blood-vessels of the Brain, in this volume.) See § 149.

Preparation.—With a preparation such as is represented in Fig. 4746, if the fornix were transected at its middle (*f*), the caudal half turned caudad, and the cephalic half, with the attached hemiseptums, removed down to the middle of the height of the portas, the appearances would be nearly as in the present figure.

Defects.—The relation of the parts shown to the rest of the brain would be clearer if there were included at least an outline of one side, or of the adjoining region. The temas are omitted, between which and the fornical margins, fimbrias, the paraplexuses enter; at the mesal side of each paraplexus should be a line, a ripa, indicating where the endyma covering the plexus was torn or cut in the separation of the fimbria. The whole, especially the lyra, is somewhat idealized.

§ 147. Prop. XCVII. Now, since the lateral connection of each hemifornix with the adjacent parts (tenia and caudatum) of the paracœlian parietes is merely membranous, and since, especially in man, the hemiseptums are so thin as to be easily torn, it is not, perhaps, strange that the conjoined hemifornices should have been described as constituting a single organ (Fig. 4737), and given a single name, *fornix*; but the morphological constitution of the cerebrum cannot be clearly perceived, unless the fornix be recognized as representing parts of the two hemicerebrums, dissociated in some degree from other parts of the same, and associated somewhat markedly with each other.

§ 148. Prop. XCVIII. *Lyra.*—When the fornix is transected through the columns (Fig. 4737) and turned caudad the exposed ventral surface, including the splenium, is seen to present lines which have been rather fancifully compared to the strings of a harp; the lyra is not a part, but merely a surface.

§ 149. Points illustrated upon Fig. 4737.—A. The general form of the velum, a double fold of pia between the thalami and the superposed cerebrum, one of the layers belonging to each of the two segments (Fig. 4735); the great veins are between the two, and others enter them from adjoining organs. The free lateral margins of the velum project into the paracœles as the paraplexuses (Fig. 4740), and its rounded apex hangs in the aula and the two portas as the auliplexuses and portiplexuses (Figs. 4742 and 4743).

B. The triangular form of the fornix; the cephalic, or "ascending" part, consisting of the two parallel fornicolumns, constituting the so-called "anterior pillar;" it expands caudad, the sides being incurved instead of nearly straight, as with the cat, and at the splenium is quite wide. Each lateral half here is practically composed of the corresponding hippocamp and fimbria, which, as they continue along the medicornu, are sometimes called the "posterior pillar."

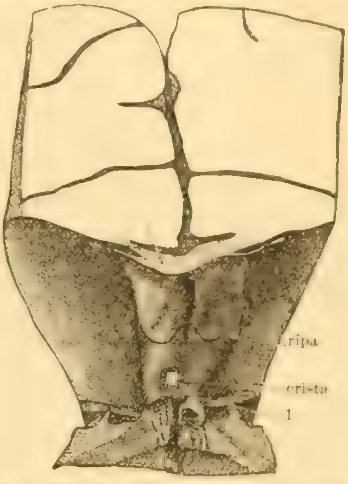

Fig. 4738.—The Fornicrista and Adjacent Parts of a Child at Term. × 1.5.

Preparation.—After transection at about the middle of the diacœle, the thalami were torn from their continuity with the fornix, leaving the irregular surface at and ventrad of 1. The lateral parts were then removed as indicated in the drawing. The paraplexus was torn from the margin of the fimbria, constituting the lateral part of the fornix; the short line at the right, ripa, is from the fimbria, crossing the intervening space, paracœle. On the left the similar line begins more nearly at the middle of the fornix, and crosses first the callosum itself, and then the callosal fissure. Before photographing, the crista was touched with white paint.

Defects.—The brain was ill preserved, and broke apart during dissection; the shading is too heavy.

C. The nature of the lyra. This is neither a separate part, nor a surface of the callosum, but the triangular, intermediate area of the ventral surface of the fornix, marked by lines which have been fancifully compared with the strings of a musical instrument. The line from 12 ends at the meson, the location of the fornicommissure or thin part connecting the thicker lateral portions.

D. The double relation of the splenium to the callosum and the fornix. The larger part, body, of the callosum consists of fibres which pass laterad, dorsad of the paracœles, constituting their roof; at the splenium some fibres pass dorsad, some caudad, some ventrad, and others in intermediate directions; now all the constituents of the fornix form parts of the floors rather than the roofs of the paracœles, and at the splenium fornix and callosum become continuous.

§ 150. Points shown on Fig. 4738.—A. The presence, in this new-born brain, of a mesal body upon the prosoterma, a little ventrad of the middle of the height of the aula, representing apparently the part which is constant in the cat (Fig. 4710).

B. The dorsal limitation of the aula and the two portæ by the line of reflection of the endyma constituting a ripa.

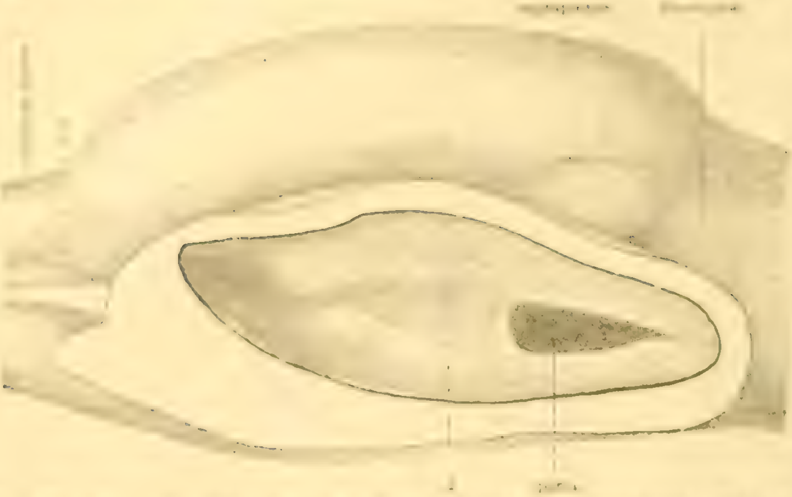

FIG. 4739.—[illegible] Cryptobranchus [illegible] of the Left [illegible] Exposed. × 6. [illegible]

C. The narrowness of the body of the fornix as compared with that of the cat and most other mammals.

D. The division of the cauda-ventral surface of the fornix, by the ripa mentioned under B, into an entocœlian area covered by endyma and forming the cephalic wall of the aula and the two portæ, and an ectocœlian area covered by pia, the dorsal or fornical layer of the velum.

§ 151. Prop. XCIX. The prosocœle's cavities, their connections, parietes, and circumscription.—As shown in Figs. 4692 and 4695, the primitive prosocœle is the single mesal, subspherical cavity of the first encephalic vesicle, a cephalic ("anterior") extension (or division?)* of the primary fore-brain (prosodiencephal). With some "fishes" this cavity remains practically undivided; but with all air-breathing vertebrates at least, Mammals, Birds, Reptiles, Amphibia, and Dipnoans, there are three main divisions, a mesal, the aula, and two lateral, the paracœles ("lateral ventricles") together with the rhinocœles ("olfactory ventricles") which, notwithstanding their constancy and presumptive, morphological importance, may be disregarded in the present connection. The more or less constricted communication between the aula and either paracœle is the porta ("Foramen of Monro").

§ 152. Prop. C. The *porta*, in a little modified condition, may be seen in the large salamander, Cryptobranchus (also called Menopoma and "hell-bender"), from the Ohio River and its tributaries. When the lateral wall of the adjacent hemicerebrum is removed (Fig. 4739), the paracœle is seen to communicate with a mesal space (aula) and thereby with its opposite and with the diacœle, through a considerable orifice, the porta. Its caudal end is narrower than the cephalic, but it is seen to be completely circumscribed by ordinary nervous walls.

§ 153. Points illustrated by Fig. 4739.—A. The simple condition of the prosencephal in this amphibian; each hemicerebrum is an elliptical, thin-walled sac, the cavity of which, the paracœle, communicates through a porta with the aula and so with the diacœle.

B. The large size of the porta, its length equalling about one-third that of the entire cerebrum; its cephalocaudal direction as compared with that of mammals, birds and reptiles, where—especially in mammals—it is dorso-ventral.

C. The absence of a rima; the prosoplexus enters the aula from the supraplexus and sends a prolongation through either porta into the paracœle, where it lies freely.

§ 154. Prop. CI. The rima.—With man, however, and with most of the other forms above named,* along a line beginning always at the porta and extending for a greater or less distance, the proper nervous parietes of the paracœle are interrupted for the intrusion of a pial extension, the paraplexus; this line of intrusion is the rima (chief part of the "great transverse fissure") already mentioned in § 42 and shown in Figs. 4705 (Macropus), 4729, 4740, 4746, and 4753.

§ 155. Points illustrated by Fig. 4740.—A. The location and general form of the paracœle; unfortunately, however, the postcornu is unusually short, and foreshortened by the way in which the preparation is viewed; but the sharp curve of the medicornu is well seen, and the projection of the precornu cephalad from the porta.

B. The absence of any indication that even in the embryo the precornu was continuous with a rhinocœle, as in the cat (Fig. 4729), and in mammals generally.

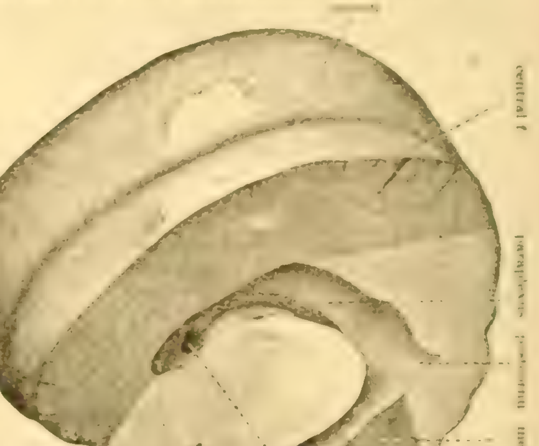

FIG. 4740.—The Left Paracœle ("lateral ventricle") Viewed Obliquely from the [illegible] × [illegible] (Fig. [illegible]) (This figure was [illegible] N. Y. Med. Journ. [illegible] 1886 [illegible])

Preparation.—[illegible]

C. The indistinctness of the colliculi, calcar, collateral eminence and occipital eminence, whether this is natural

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* [illegible]

* [illegible] Amer. Naturalist, June, 1887.

(owing to hydrocephalus) or due to the pressure of the alinjected alcohol it is impossible to say.

D. The location and size of the porta, which is shown on a larger scale in Fig. 4742.

E. The location of the paraplexus and of the rima through which it enters, covered, however, by the endyma (Fig. 4765).

§ 156. Prop. CII. The ease with which the two margins of the rima are separated by the tearing of the membranes during the removal or examination of the brain has occasioned a somewhat general impression that (1) there is a natural "great transverse fissure" communicating between the encephalic cavities and the ectal surface of the brain; (2), the porta is merely a part of this fissure. The whole subject has been considered at some length by the writer (*New York Medical Journal*, May 10, 1884, pp. 513–516) and here the following figures may be allowed to illustrate the principal points.

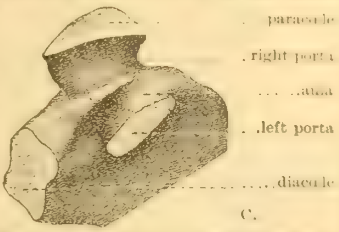

FIG. 4741.—Cast of Aula, Portas, and Part of Diacœle. × 1.5. The main object of the figure is to demonstrate the complete circumscription of the porta, and its independence of the rima (§ 41). The material used was a mixture of wax and gutta-percha. The mesal ridge which represents the aulic recess just dorsad of the precommissure, Fig. 4743. The figure should have been so placed as to make this ridge vertical.

§ 157. Prop. CIII. The porta is completely circumscribed, so that a cast has a definite outline, viz., that of an elongated ellipse, its longer diameter, 4–6 mm., its shorter 1–3 (see Figs. 4741–4743).

§ 158. Points illustrated upon Fig. 4743.—A. The existence, form, size, and complete circumscription of the two portas ("Foramina of Monro").

B. The extent of the aula, the mesal division of the prosocœle, and the cephalic or prosocœlian constituent of the "third ventricle." It includes the interval between the portas, extending ventrad so as to include the precommissure, only part of which appears in the figure.

C. The existence of the aulic recess, a subtriangular depression between the precommissure and the two fornicolumns; the line from the word *aula* ends in this recess; on the cast shown in Fig. 4741, it is a ridge.

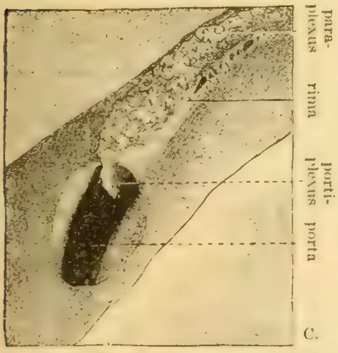

FIG. 4742.—The Left Porta and Adjoining Parts of the Alinjected Brain shown in Fig. 4740. 385; × 3. The form of the precornual orifice of the porta appears more distinctly, and the endyma is seen clearly to be reflected upon the portiplexus from the adjoining surfaces. Just dorsad of the line from *rima* are a few artificial rents in the endyma.

D. The peculiar curvature of the fornicolumns. They converge dorsad, curving at the same time caudad, so as to appear as cut ends in this transection; ventrad they diverge, are twisted somewhat, and again curve caudad, so that their cut ends should appear again just dorsad of the optic tracts, as shown in Fig. 4732.

E. The relation of the precommissure to the fornicolumns, which pass just caudad of it. In a figure including a greater width of this region, the cut ends of the precommissure would appear at the side, as in Fig. 4732.

F. The reflection of the endyma upon the plexuses from the fornix and thalami, at two points upon each side; such lines of reflection constitute a ripa.

G. The continuity of the hemiseptums with the callosum dorsad and the fornix ventrad.

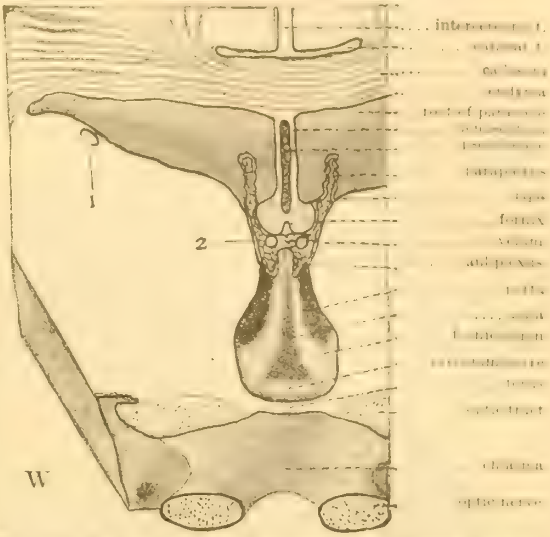

FIG. 4743. The Two Portas, as Seen from the Aula, Looking Obliquely Dorso-cephalad. 2345; × 1.5. (Compare with Figs. 4742 and 4744.) 1, Tenial vein; 2, velar vein; the number rests upon the thalamus.

Preparation.—From a brain, the arteries of which had been injected with the red glue mixture, and the cavities with alcohol, a transection was removed, 12 mm. thick, so as to include the chiasma; for security of handling it was trimmed down so as to include little more than the parts represented. The optic nerves were divided obliquely, to show their cut ends more fully.

Defects.—The alba and cinerea are not distinguished, and the figure is not upon a scale large enough to show certain details as to the connections of the velum and plexuses. The divided ventral ends of the fornicolumns were inadvertently omitted, but may be seen in Fig. 4732. A still greater enlargement of the right porta is shown in the article Malformations of the Brain.

§ 159. Points illustrated upon Fig. 4744.—A. The existence of the two portas, and their obviously natural

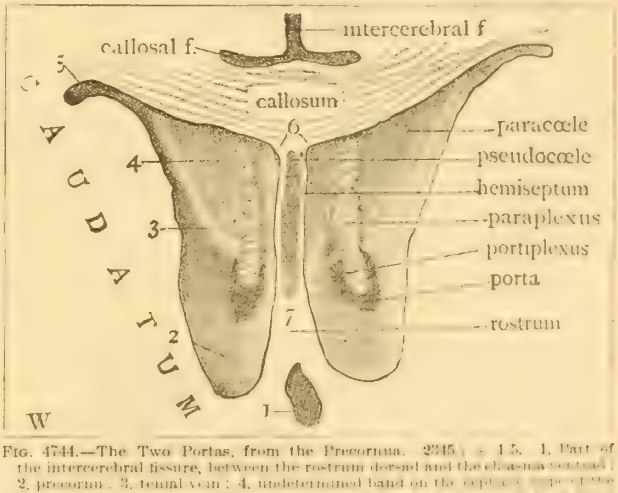

FIG. 4744.—The Two Portas, from the Precornua. 2345; × 1.5. 1, Part of the intercerebral fissure, between the rostrum dorsad and the chiasma ventrad; 2, precornu; 3, tenial vein; 4, undetermined band on the [illegible] of the thalamus; 5, dorsal part of right paracœle; 6, the short [illegible] point to the locations of veins (septal ?) at the angle of junction of the hemiseptums with the callosum; 7, dorsal of the junction of the hemiseptums with the rostrum is a small (septal ?) vein at either side.

Preparation.—See under Fig. 4743. The slice including the portas is 12 mm. thick; the caudal (aulic) aspect is shown in Fig. 4743, the cephalic (precornual) in this.

Defects.—The shading does not indicate with sufficient distinctness that the entire surface, and plexus at either side dorsad of the porta, [illegible] caudad beneath the callosum, and is not continuous with the [illegible]. As in Figs. 4742 and 4743, the lines representing the callosal fibres are [illegible]. Other preparations and figures upon a still larger scale are needed, in order to exhibit the somewhat intricate relations of the parts about the porta. The morphological importance of the entire aulic region can hardly be overestimated.

conditions. This point, already shown in several previous figures, is here reiterated because this aspect of these callosa is almost [illegible], and [illegible] a distinguished French anatomist, Mathias Duval, has declared (*Progrès Médical*, Nov. 22 and 29, 1879) that when one finds a communication between the middle and lateral ventricles in an adult human brain it results from an artificial perforation: see the writer's comments in "Amer. Assoc. Proc., 1884," p. 506, and *N. Y. Med. Journ.*, May 10, 1884.

B. The [illegible] of the callosum in two places, viz., dorsad near the genu and ventrad through the rostrum; the part of the [illegible] or [illegible] here shown. The [illegible] continued by the general curve of the callosum (see Figs. 4711 and 4718).

C. The continuity of the [illegible] with the corresponding [illegible]; so far as the porta is concerned the former may be compared to a [illegible] partition, and the latter to a door post (see also Figs. 4726 and 4727).

§ 160. Prop. CIV. The portal boundaries are as follows: caudad, the thalamus (perhaps the tenia); cephalad, the [illegible]; ventrad, the junction of the two; dorsad, the endyma reflected from the thalamus and fornix column upon the intruded portiplexus (Fig. 4745). So long as this endyma retains its adhesions, so long the circumscription of the porta is complete.

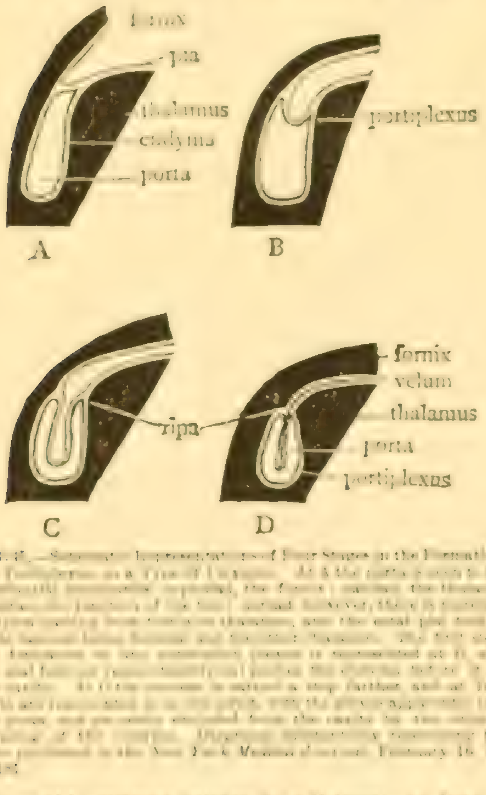

FIG. 4745.—Schematic Representations of Four Stages in the Formation of the Portiplexus as a Type of Plexuses. [illegible] New York Medical Journal, February 16, 1884, p. 18.

§ 161. Prop. CV. The exact conditions and relations of the rima, paraplexus, tenia, fimbria, and thalamus near the porta have not been as yet clearly made out. Preparations should be made with special reference to their elucidation, and figures upon a very large scale. Excepting the metapore ("Foramen of Magendie") no part of the brain involves so many and so important morphological questions; see the difficulties and doubts admitted under Fig. 4755.

§ 162. Prop. CVI. The colliculi. This collective term is applied to the rounded eminences and ridges which project into the paracœles ("lateral ventricles") from their parietes. They are the caudatum (corpus striatum), hippocamp ("*Hippocampus major*"), calcar ("*Hippocampus minor*"), collateral eminence, occipital eminence, and amygdaline eminence. Excepting, perhaps, the first and the last, each of these represents a corrugation of the entire thickness of the parietes, the entad elevation (colliculus) being collocated with an ectal depression (fissure); this collocation is indicated in the list of total fissures, § [illegible].

§ 163. Points Illustrated upon Figs. 4746 and 4747.—

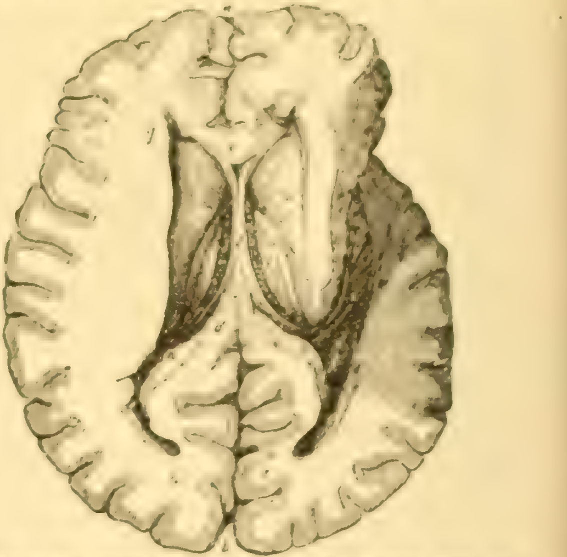

FIG. 4746.—The Paracœles ("lateral ventricles") Exposed from the Dorsal Side. [illegible]

A. The general relation of the paracœles to the cerebrum in the adult (compare Figs. 4692 and 4709).

B. The thickness of most of the parietes as compared with the fetal condition, as seen in Fig. 4708.

C. The existence of special ental elevations, colliculi, viz., the caudatum (*k*), the calcar (*o*), the hippocamp (*g*), and the collateral eminence (*u*).

D. The apparent representation of the thalamus as a constituent of the paracœlian floor, as if it were an additional colliculus; for explanation of this appearance see § 172.

E. The presence of the "white line of Vicq d'Azyr," a thin stratum of a white color between the strata of the cinerea (cortex) in the occipital region.

F. The peculiar curve of the [illegible] and hippocamp, whence the latter is sometimes called *Ammon's horn*.

G. The terminal expansion and digitation of the hippocamp, *pes hippocampi*; see Fig. 4752.

H. The relation of the collateral eminence as a more or less elevated triangular interval between the hippocamp and the calcar.

§ 164. Prop. CVII. The *callosal eminence*.—Besides the colliculi named in § 162, all of which are more or less distinct in at least some adult brains, there is one which is perfectly obvious in some fœtuses (Fig. 4748, 1), and which, from its apparent collocation with the callosal fissure (Fig. 4757), may be called, provisionally, the callosal eminence. It, the hippocamp and the occipital eminence form an irregular triradiation. Its commencement and disappearance require further observation, but its unbroken continuity with the hippocamp confirms the idea that the callosal and hippocampal fissures are essentially parts of one, merely deflected by the splenium of the adult.

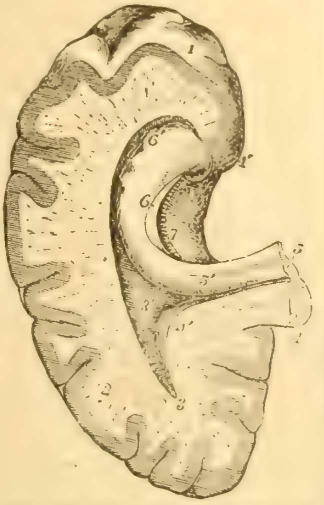

Fig. 4747.—The Left Hippocamp and Adjoining Parts. × 5; from Quain (altered from Hirschfeld and Leveillé). 1, Apex of the temporal lobe; 1', uncus; 2, cut surface of the cerebral medulla surrounded by the cortex; 3, at the apex of the postcornu; 3', collateral eminence; 4, part of the splenium, nearly medisected; 4', points to the calcar; 5, cut end of the lateral portion of the fornix which is continued at the hippocamp; 5', and the fimbria (6); 6, the fimbria; 6', the terminal expansion of the hippocamp, called *pes hippocampi*; 7, dentate gyre ("*fascia dentata*"). See § 163.

Preparation.—The left occipito-temporal region of the cerebrum was separated from the rest, together with a part of the splenium and fornix, and the dorsal and lateral parietes of the postcornu and medicornu sliced away so as to expose nearly the entire extent of the cavities.

Defects.—The specimen had not been alinjected, and the figure looks somewhat diagrammatic; especially as to the dentate gyre (7); the actual extremity of the medicornu does not appear (see Fig. 4752). There is no indication, along the free margin of the fimbria, that one surface of this lamina was covered by pia and the other by endyma, and that they were continued in and upon the removed paraplexus.

§ 165. Prop. CVIII. The relative size of the colliculi is not the same in the adult as in the fœtus. This is clear from the comparison of Fig. 4748 with Figs. 4736, 4740, and 4746. The callosal eminence may disappear wholly; the occipital is seldom recognized; the collateral is certainly less prominent in the adult than in the fœtus (Fig. 4748).

§ 166. Points illustrated upon Fig. 4748.—A. The contiguity of the margins of the fimbria and the tenia (the edge of the caudatum) with just room for the entrance of the paraplexus, and the concomitant complete exclusion of the thalamus from the paracœlian floor (compare Figs. 4746, 4749, and 4751).

B. The existence of an ental ridge (1) at this period, continuous and corresponding with the hippocampal and callosal fissures; whether it extends still further cephalad, as in Fig. 4757, cannot be ascertained from this specimen.

C. The branching off of a ridge corresponding apparently to the occipital fissure, and representing the adult occipital eminence.

D. The existence of two intermediate ridges, apparently the calcar and collateral eminence.

§ 167. Prop. CIX. With all mammals other than man (and perhaps the apes) the margins of the rima are, throughout their whole extent, separated only so far as to permit the intrusion of the paraplexus; nor does this adhesion yield at all in cases of hydrocephalus, observed by the writer in dogs and cats.

§ 168. Prop. CX. With the human fœtus, also, up to the estimated age of four months (Figs. 4748 and 4749), at least, the tenia and the fimbria are closely apposed, as closely, that is, as they can be and yet allow the plexal intrusion; at this age, therefore, the human thalamus is as perfectly excluded from the paracœle as it is in mammals generally.

§ 169. Points illustrated by Fig. 4749.—A. That, at this age, the paracœles extend much farther dorsad than in the adult, far beyond the level of the callosum.

B. That the paraplexus is relatively more extensive.

C. That the caudatum is relatively larger.

D. That the margin of the fimbria reaches the groove between the caudatum and the thalamus, which probably represents the tenial sulcus of the adult.

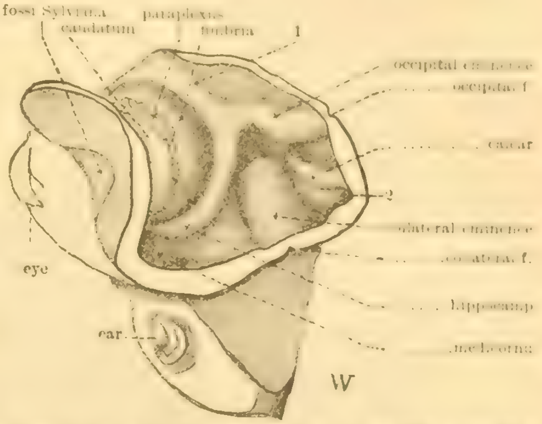

Fig. 4748.—Left Hemicerebrum, Laid Open, of a Fœtus Weighing 88 grams (3 ounces), Measuring 15 ctm. from Heel to Bregma, and Estimated at 14 Weeks. 2683; × 1.5. See § 166.

Preparation.—The fœtus was received fresh; the head was cut off and pinned by the neck to a cork loaded with sheet lead; a shawl-pin was inserted as a handle at one side of the head. A slit was made through the scalp at the lateral angle of the prefontanelle, and the guarded cannula adjusted so that ninety-five per cent. alcohol should enter the paracœle gently, with opportunity for egress at the side of the cannula. After six hours the alinjection was discontinued, but the specimen remained in alcohol for two days, when the scalp was removed and the specimen placed in ten per cent. nitric acid. After three hours the calva was so far decalcified that it could be cut away with the scalpel and scissors without jarring the very delicate brain. The left hemicerebrum was then exposed as indicated, and the nape of the neck removed to expose the collateral fissure. Upon a larger scale some of the points would have appeared more clearly.

E. That the thalamus is therefore absolutely excluded from the paracœlian floor, without even the appearance of representation which exists in the adult.

§ 170. Prop. CXI. But with all human adults (perhaps also with the new-born, and possibly with fœtuses during the latter months) the tenia and fimbria, for most of their length, are separated by an interval, 2–7 mm. in width, narrowing at the porta and in the medicornu. This interval is filled by (1) the paraplexus, which usually retains its attachment to the fimbria rather

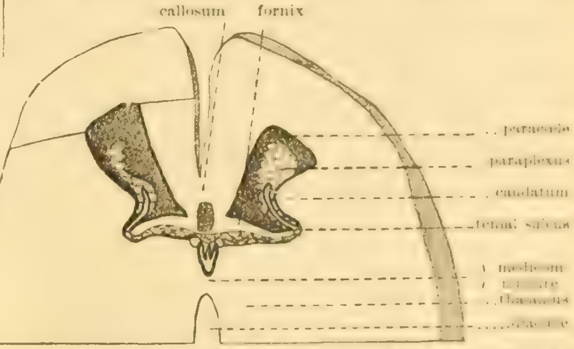

Fig. 4749.—Transection of the Brain of a Fœtus, about 16 ctm. from Nates to Bregma, and Estimated at Four Months. 1816; × 1.5. See § 169.

Preparation.—The fœtus was received in alcohol, not very well preserved. The calva was cut away with scissors, and the dura and pia removed. The entire brain was then transected at the level of the medicornu in situ, but only the dorsal half of the divided surface is included in the figure; it is the cephalic aspect of the caudal part. The two lines crossing the right hemicerebrum indicate the plane of the section shown in Fig. 4764.

than the sprout; (2) an extension of the contents from the margin of the tela; (3) in some cases, perhaps, a membranous [illegible] through the [illegible] of the [illegible] itself; the parts have the appearance (Figs. 4736 and 4751) of having been stretched by the expansion of the adjacent thalamus, which is very much in the human adult.

§ 171. Points illustrated by Fig. 4750.—A. The completeness of the paracoelian floor, irrespective of the thalamus, which he made to appear in Fig. 4746 between the paraplexus and the tenia.

B. The existence of ridges (2, 3, 5, and 7) not yet commonly recognized, and perhaps not invariably present.

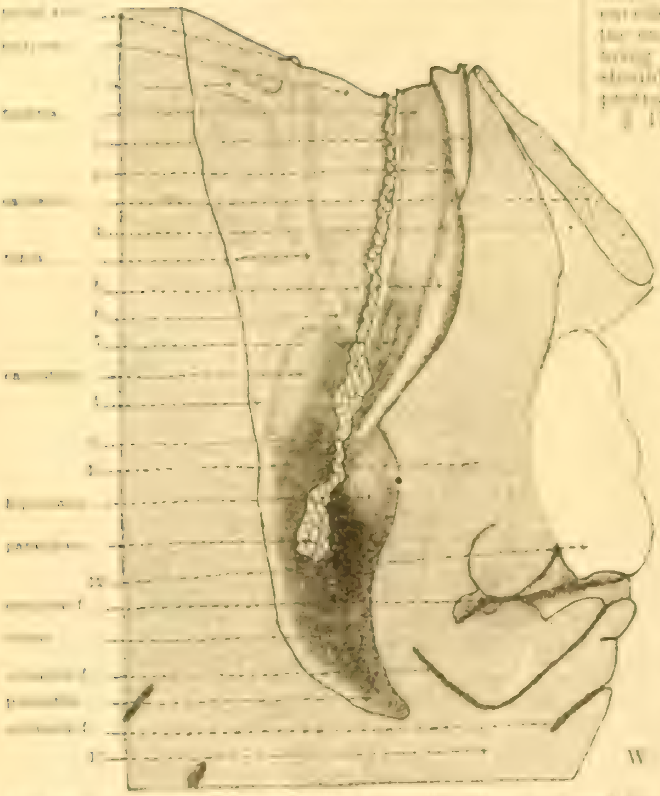

FIG. 47[illegible].—The Caudal Part of the Left Paracoele, Viewed from the Dorsal Side, and [illegible]. [illegible] 2, 3, 5, 7, [illegible] ridges of the floor [illegible]; 12, the surface of the hippocampal gyre; [illegible]

[illegible]

C. The approximate coincidence of the band marked *fornix* (?) with the subjacent fornical vein.

§ 172. Plate CXII. The common impression as to the appearance of the thalamus may be ascribed to two sources, viz.: (1) Since the endyma is thin and transparent, and often more or less closely attached to the dorsal surface of the thalamus, one might (unless already well grounded in morphological principles from the study of embryology and comparative anatomy) regard the thalamus as a constituent of the paracoelian floor in the same sense as is the caudatum or the hippocampus; but since the entire dorsal surface of the thalamus is, from its beginning, ectocoelian and separated from the entomedian mesal surface by the fimbria and its sulcus, and a line of ependymal reflection, rima, its appearance as a genuine portion of the paracoelian parietes is as little to be admitted without further inquiry as would be the alleged appearance of the cerebellum in the same place. (2) The delicacy of the membranes, the readiness with which they are detached along a rima, the rough handling to which brains are commonly subjected during the ordinary processes of removal and examination, the slight degree in which preservatives can reach the parts in question when the entire organ is merely immersed as usual, and, finally, the fact that some specimens prepared for macroscopic purposes do not well preserve the ependymal attachments: all these conditions conspire to bring it about that the endyma across the velar rima should be torn, and the dorsal surface of the thalamus protrude through the rent, as in Fig. 4746.

§ 173. Points illustrated upon Fig. 4751.—A. The main point is the continuity of the floor of the paracoele ("lateral ventricle") irrespective of the dorsal surface of the thalamus, and the concomitant exclusion of this diencephalic mass from this portion of the prosencephalic cavity; but so many other points are shown incidentally that the figure will be described in detail.

Beginning at the dorsal side of the figure, the intercerebral fissure is seen to separate the apposed mesal surfaces of the hemicerebrums. The arachnoid dips into this fissure to a certain depth, so as to pass around the ventral margin of the falx (not shown in the figure), since this has (as seen in Fig. 4711) a curved margin, and becomes narrower (dorso-ventrally) cephalad; the extent of the arachnoidal fold varies at different levels; in the specimen here figured, for example, which is about 1 cm. thick at the level of the callosum, the arachnoid crosses 5 mm. dorsad of the callosum on the caudal aspect and 8 mm. on the cephalic. The pia, however, follows the apposed hemicerebral surfaces to and into the callosal fissure at either side and is continuous upon the dorsal surface of the callosum. Of the vessels the figure includes only the two parallel precallosal arteries (4). The callosum itself presents a slight mesal elevation, which is more distinct at the cephalic side of the section and of a somewhat different color; there is no distinct evidence of the longitudinal striæ or of the furrow caused apparently by the pressure of the arteries, and described by the writer in the *N. Y. Med. Jour.* for April 5, 1884, p. 374.

The callosum extends laterad and likewise dorsad to form the roof of the paracoele, and it is to be noted that the lateral portion of this cavity would be opened by a horizontal section at the level of the dorsal surface of the callosum. Hence, as remarked by Dalton (*Medical Record*, April 19, 1884) and confirmed by the writer (*N. Y. Med. Jour.*, April 5, 1884, p. 374), the appearance commonly described and figured under the name of "centrum ovale majus" seldom, if ever, exists. For the condition of things in fœtal brains see Fig. 4749, § 169.

Ventrad of the callosum is the fornix, connected therewith by a thin septum, the hemiseptum at either side of a mesal cavity, the pseudocoele. The lateral margin of the fornix is formed by the fimbria (corpus fimbriatum).

At the extreme left of the figure the lateral wall of the paracoele is seen to be formed by a cinereal mass, the caudatum. By reference to Figs. 4723 and 4736 it will be seen that this narrows rapidly from the cephalic end (caput) as a slender prolongation (cauda); but this cauda is really twisted somewhat upon its longitudinal axis so as to constitute, in at least part of its course, not only the side but a part of both the roof and floor of the paracoele. In the figures just mentioned the roof portion and part of the lateral is removed, leaving only the floor portion. Along the mesal border of the cauda there passes a vein (3), the tenial vein, which may be regarded as indicating the boundary between the caudatum and the thalamus.

Projecting mesad of the vein is seen a lamina, consisting evidently of the paracœlian endyma, and also, at least near the caudatum, of some nervous substance; this is, or includes, the white band named *tenia* in this article, but commonly called *tænia semicircularis* or *stria cornea*.

All the parts so far described are unquestionably constituents of the prosencephal; the remaining portions shown in Fig. 4751 belong to the diencephal. The walls of the diacœle are the thalami, of which the figure includes only the portions dorsad of the level of the medi- and postcommissures (see Fig. 4711).

The mesal surface is covered by endyma, which is continued over the low ridge called habena ("habenula") seen from the mesal aspect in Fig. 4711, and from the dorsal in Fig. 4732. Just dorsad of the habena is a slight furrow, the habenal sulcus; here the endyma meets the pia covering the dorsal aspect of the thalamus, and is reflected with it dorsad and then mesad toward the opposite side. Instead of passing horizontally across the interval between the thalami, however, the endyma is deflected over the two vascular plexuses (folds of pia or vessels therefrom) which hang in the diacœle. The habena and its sulcus, more accurately, perhaps the latter, constitute the boundary line between the mesal, entocœlian, endymal surface of the thalamus and the dorsal, ectocœlian, and pial surface, which extends dorso laterad.

Between the dorsal surface of the thalamus and the ventral surface of the fornix (including, of course, the fimbria), the pia is freely separable, and appears to consist of but a single layer, but laterad it is traceable to the paraplexus, and it is almost inconceivable that a plexus should be formed of a single layer of pia as a free edge covered by endyma.* When, however, this fornico-thalamic pia is traced mesad, it is found to separate into two layers, a dorsal, belonging to the fornix, a ventral, constituting part of the diacœlian roof (diatela) with a pair of arteries, a pair of veins, and numerous smaller vessels in the intervening space. The ventral layer is not separable (in man) from the diacœlian endyma, but the dorsal not only may be detached from the fornix in an alcoholic specimen, as may the pia from most of the surfaces which it covers, but here, excepting at the margins, the disjunction was almost spontaneous, and there is a distinct space (8) between it and the fornicommissure, bounded at the sides by the thicker (hippocampal) constituents of the fornix. This double curtain of pia is the velum (interpositum), which belongs equally to the diencephal and to the superposed prosencephal; were it possible in separating the two segments, the dorsal layer should accompany the cerebrum, and the ventral remain attached to the thalami; the continuity of the two is seen at the aula and the two portæ, as well as along the entire margin of the paraplexus; see Figs. 4735 and 4745.

Corresponding with the margin of the fimbria, the dorsal surface of the thalamus presents a shallow groove, the fimbrial sulcus ("sulcus choroideus" Fig. 4732); laterad from this the surface is nearly regular, and overlaid partly by the paraplexus and a membrane apparently endyma only, and partly by the thin but more substantial lamina (tenia ?) already described as an extension of the caudatum.

The entire dorso-mesal surface of the thalamus, instead of being homogeneous, as it has been sometimes figured and described, may be divided, first and most sharply into a mesal, or entocœlian, and a dorsal, or ectocœlian, portion, the boundary between the two being the habena and its sulcus. The dorsal surface itself presents a twofold division into a subfornical (B) and a parafornical (C and D), separated by the fimbrial or choroid sulcus. Finally, the parafornical area is covered partly by the endyma and plexus and partly by the tenia, and may thus be distinguished as subplexal (C) and subtenial (D), there being occasionally a furrow, the tenial sulcus between them. The desirability of discriminating between

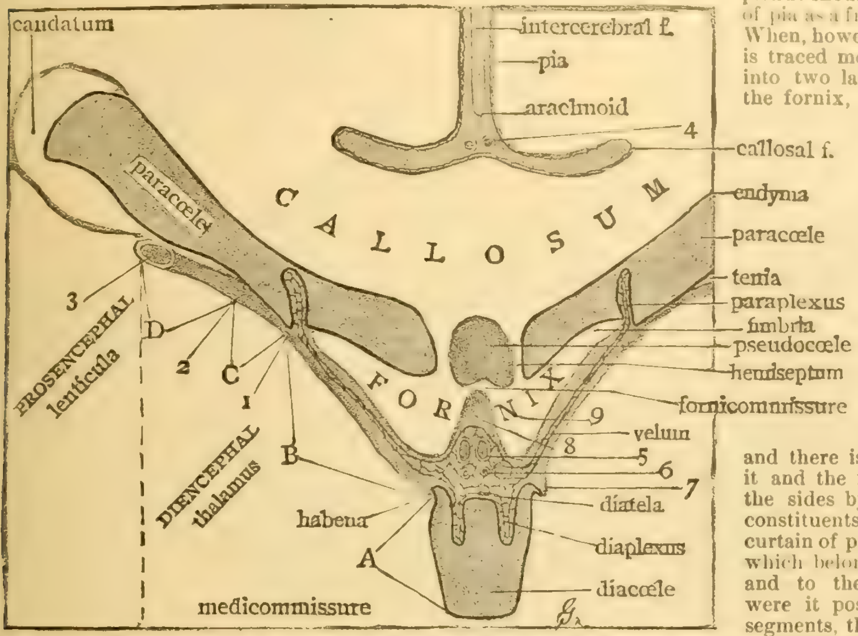

FIG. 4751.—Transection, Partly Schematic, of the Fornix and Adjacent Parts at a Level Corresponding with the Interval Between the Medicommissure and the Postcommissure. 1824; × 2.5. 1, Fimbrial sulcus ("sulcus choroideus); 2, tenial sulcus (in some specimens); 3, tenial vein; 4, precerebral arteries; 5, velar veins; 6, velar arteries; 7, habenal sulcus; 8, interval (natural ?) between the fornicommissure and the velum; 9, lateral part of the fornix (hemifornix); A, mesal, endymal surface of thalamus; B, C, D, zones of its dorsal surface; B, subfornical; C, subendymal; D, subtenial.

The figure represents the caudal surface of the transection; the observer is looking cephalad, and his right coincides with the right of the specimen and the figure; the two sides are substantially identical but less is shown upon the right; the meson of the figure, the anatomical middle of the various parts and cavities represented, is dextrad of the middle of the area covered by the figure. Throughout the figure the cavities are shaded and the blank areas represent transected surfaces. The arachnoid is represented by a narrow, straight line, the pia by a corrugated line, and the endyma by a heavy line; the endyma is made to adhere closely to the entocœlian surfaces, but the pia and arachnoid are separated slightly from the parts which they cover.

Preparation.—See Fig. 4736, representing another transection of the same brain. The cœlian parietes were thoroughly hardened before the brain was removed from the skull, and the membranes and plexuses have retained their connections notwithstanding much handling and considerable transportation. There is some distortion and dislocation of the loosely connected parts about the fornix, but it has been possible to clear up most of the doubtful points by comparison of the two sides and with adjoining sections. So far as respects the exclusion of the dorsal surface of the thalamus from the paracœle, the preparation affords unequivocal evidence.

Defects.—As in several other figures representing transections of plexuses, it has been assumed that a plexus consists of a fold of pia covered by endyma; for present purposes it matters not whether there is a complete fold of the pia, or merely an extension of vascular loops. The ventral lamina of the velum is made too low. The medicommissure, the dorsal margin of which is included at the ventral side of the figure, did not actually appear in this section, which was just caudad of it, but is introduced as a readily recognized landmark.

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* The expression is qualified in view of the conditions at the margin of the metapore ("Foramen of Magendie"), where the pia is supposed to either terminate or become continuous with the endyma, and where a plexus might apparently be developed.

these lesions will appear in connection with Fig. 4755, which reveals different and perhaps anomalous conditions [illegible] described.

So far as this preparation is concerned, there is absolutely no indication of entrance to any part of the thalamus dorso-laterad of the fimbrial sulcus; on the contrary, the endyma [illegible] continuously about each paraplexic [illegible], in turn, the ental surface of the thalamus, the [illegible], the tenia, the paraplexus, the fimbria, the [illegible] portion of the fornix, and the [illegible] septum, back again to the callosum.

§ 174. Points illustrated upon Fig. 4752.—A. The existence of substantial walls of nervous substance about

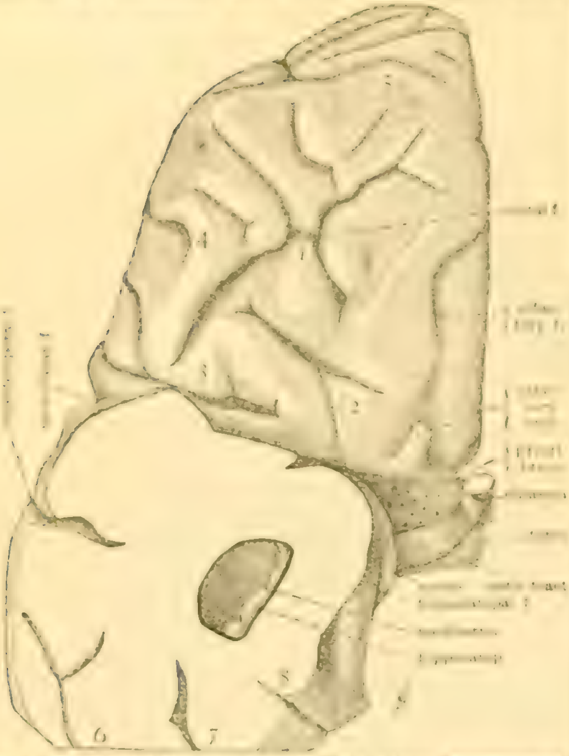

FIG. 4752.—Ventral (ectal) Aspect of the Right Fronto-temporal Region of the [illegible] [illegible] [illegible] [illegible] [illegible]
(Natural size.) See Fig. 4751.

the medicornu at the distance of 1 ctm. from the tip of the temporal lobe.

B. The coincident non-extension of the rima ("great transverse fissure") to the extremity of the medicornu as implied in most anatomical works, *e.g.*, Quain, ii., 346.

C. The existence of digitations at the ventral end of the hippocamp (pes hippocampi).

D. The non-extension of the hippocamp to the extremity of the medicornu, as stated in Quain, ii., 345.

E. The dilatation of the medicornu in hydrocephalus.

F. The efficacy of alinjection in maintaining the size of an encephalic cavity and preserving the contents of its parietes.

G. The nearly typical zygal, or H shape, of the orbital fissure; see Fig. 4750.

§ 175. Page CXIII. The rima extends from the porta to near the extremity of the medicornu, but for about 1 ctm. from its extremity the margins are substantial, Fig. 4752. The transition to the rima is constituted by the slender part, pala, which connects the two rimal margins, fimbria and tenia (Figs. 4753 and 4754). This thin portion has, as seen, a shape like the blade of a turf-cutter. It was figured and described by the writer in 1884 (N. Y. *Med. Jour.*, April 5th, Fig. 48, p. 376) and in 1886 ("Anatomical Technology," 490). In the preparation was prepared for it, the pala is not distinctly shown in any of the figures in this article, but in Fig. 4753 it would constitute the thin lamella at the ventral end

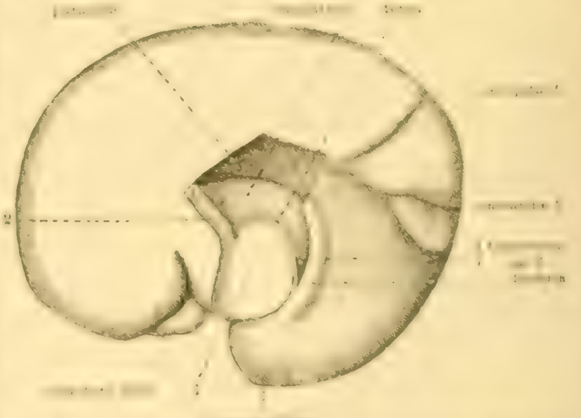

FIG. 4753.—[illegible] [illegible] [illegible] [illegible] [illegible]

of the fimbria; in the diagram, Fig. 4754, the pala is seen in transection at B.

§ 176. Points illustrated upon Fig. 4753.—A. The early and distinct formation of the medicornu; see also a figure in the article Malformations of the Brain.

B. The continuity of the two margins of the rima, the fimbria and tenia, near the tip of the temporal lobe, the place of their union, at and after birth, being somewhat distinct, the pala.

§ 177. Page CXIV. With some specimens the interval between the paraplexus and the caudatum seems to be

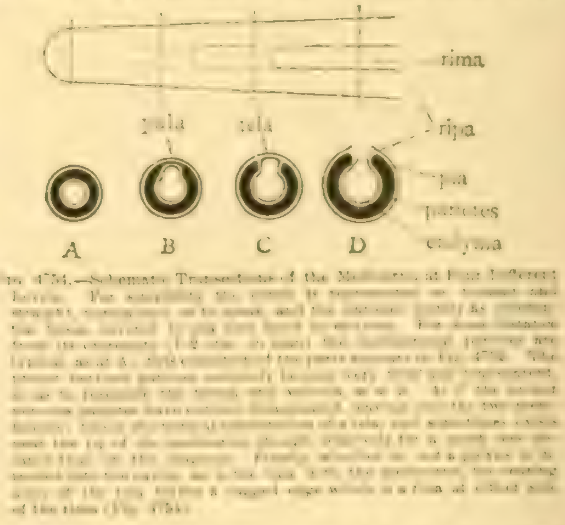

FIG. 4754.—Schematic Transections of the Medicornu at Four Different Levels. [illegible] [illegible] of the rima (Fig. 4755).

occupied by a somewhat substantial lamina, separable from the thalamus, continuous with the caudatum, and perhaps merely a special development of the tenia, but requiring further investigation (Fig. 4755).

§ 178. The point illustrated upon Fig. 4755 is the continuity of the paracoelian floor from hippocamp to caudatum without the intrusion of the thalamus. This figure is to be studied in connection with the transection (Fig. 4751) and the dorsal view of the floor in Fig. 4746.

There are, however, differences between these and other preparations which are not easy to explain, excepting upon the general supposition that a region in which the conditions are, apparently, peculiar to the human brain, might naturally be expected to present individual peculiarities and even anomalies.

§ 179. Prop. CXV. There seems to be considerable variation in the details of the parts involved in the apparent representation of the thalamus within the paracœle; this is perhaps to be expected, since the conditions that have made the usual statements possible constitute a great and perhaps peculiar modification of the primitive and typical relations, indeed, almost a malformation.

It is hoped that the foregoing descriptions and figures may at least serve to induce anatomists to investigate the subject in all its bearings.

§ 180. Prop. CXVI. The *cerebrum* proper comprises the prosencephal less the olfactory bulbs and crura.*

in pairs; 2, although its sides are formed by cortex, the bottom is alba, the callosum; 3, although the pia has the usual relation, the arachnoid, instead of passing directly across, dips into it to a greater or less depth on account of the falx (Figs. 4711 and 4751); 4, it is, in one sense, a superfissure (§ 261) since in its depths are concealed the callosal fissures. Respecting points 2, 3, 4, however, see, in the article Malformations of the Brain, cases where the callosum is undeveloped, or the cerebrum forms a scarcely divided mass.

§ 183. Prop. CXIX. *Cerebral lobes.* For topographical convenience, and not because they represent perfectly natural divisions, either anatomical, histological, or physiological, each hemicerebrum may be regarded as forming six lobes, as indicated in the fissural diagrams (Figs. 4769 and 4770).

§ 184. Prop. CXX. One of these lobes, the *insula* (*lobus opertus*, "central lobe"), is nearly or quite covered in the adult brain by folds (operculums) from the adjoining lobes (Figs. 4767 and 4778); excepting at part of the ventral side the insula is surrounded by an irregular furrow, the circuminsular fissure (Figs. 4783 and 4785); on the mesal aspect the insular lobe may be regarded as bounded approximately by the hippocampal and callosal fissures.

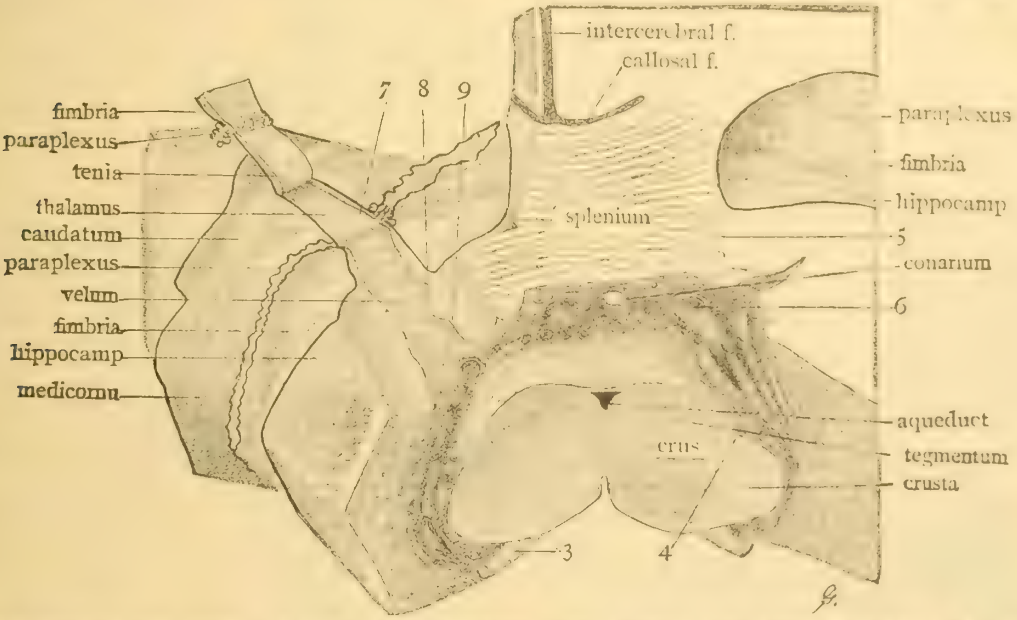

FIG. 4755.—Dissection, Partly Schematic, of the Floor of the Left Paracœle ("lateral ventricle") Caudal Aspect (2345 and 2347; × 1.5). Compare in part with Fig. 4724. 4. Lateral sulcus of the mesencephal; 3, oculo-motor nerve; 5, line of somewhat sudden deflection of the splenial fibres caudad into the occipital lobe; 6, large vein; 7, fimbrial sulcus; 8, angle between the fimbria and the hippocamp; 9, hippocampal fissure.

Preparation.—The arteries were injected with the red glue mixture, and the cavities with alcohol. When hardened, a thick slice was taken by a transection at about the middle of the length of the callosum and another at the splenium, just shaving off the tip of the conarium. The ordinary transection of the brain stem between the mesencephal and epencephal was modified by carrying two sections cephalo-mesad, meeting at the base of the valvula. On the right of the cerebrum the parts were left undisturbed excepting that the paraplexus was raised so as to expose the floor of the cavity. On the left, a thin slice of the hemicerebrum is left attached to its opposite by the pia. In order to expose the paracœlian floor as completely as possible from this point of view, the sections had to be made in many directions. The paraplexus was trimmed down for a certain distance; then a wedge-shaped piece was cut from the thick caudal wall, hippocamp, etc., including part of the thinner floor, fimbria, thus exposed the velum, the double fold of pia between the dorsal surface of the mes- and diencephal and the ventral surface of the fornix. Very cautiously then the two parallel incisions were carried across the floor to and into the caudatum constituting the lateral wall; the strip so enclosed was then lifted; it included (1) a piece of the fimbria; (2) the disconnected part of the paraplexus; (3) a strip of the thin lamina intervening between the plexus and the caudatum; in 2347 all these were found separable from the dorsal surface of the thalamus, substantially as in the transection, Fig. 4751; in 2345 there were complications which should form the subject of monographic consideration.

Defects. The defects of the figure are due mainly to the attempt to combine the appearances presented by two different preparations.

§ 181. Prop. CXVII. The cerebrum consists (Fig. 4688) of two lateral, hemispherical masses, the *hemicerebrums* ("cerebral hemispheres") united primarily by the walls of the aula from which they were developed as lateral protrusions, and also by secondary junctions (or extensions of junctions) the fornix and callosum (Figs. 4698, 4733, 4735, and 4751).

§ 182. Prop. CXVIII. The interval between the apposed, mesal surfaces of the two hemicerebrums is the *intercerebral fissure* ("interhemispheral," "sagittal" or "great longitudinal") (Figs. 4698, 4732, 4735, and 4736); it differs from ordinary fissures in the following respects: 1, It is mesal or azygous, while all others are lateral or

§ 185. Prop. CXXI. The other five lobes have more or less complete natural boundaries on either the lateral or mesal surface, but not on both. The primary division is by the line of the central fissure (Fig. 4759) into a frontal region and an occipito-temporo-parietal region. The former, although commonly accepted as a single lobe, is so extensive as to be conveniently subdivided by a line continued dorso-cephalad from the presylvian fissure into a *postfrontal* and *prefrontal* lobe, the latter including the orbital surfaces.

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* To include under the name *cerebrum* the thalami and gemina is to disregard the plain facts of development and comparative anatomy; it is sometimes convenient, however, to group the thalami with the striata (caudatums and lenticulas) under the physiological term "basal ganglia."

§ 186. Prop. CXXII. The region caudo-ventrad of the central fissure line is divided first by the occipital fissure into a parietal and an occipito-temporal portion, and the latter again into a temporal and an occipital lobe by a line from the preoccipital fossa (Fig. 4769,) to the end of the sylvian on the lateral surface, and to the convexity of the splenium on the mesal. In a general way, but by no means accurately, these lobes coincide with the cranial bones for which they are named.

§ 187. *List of the Interlobar Fissures with the Lobes Bounded by them.* (*Figs.* 4768 *and* 4769.)

Fissure.	Aspect.	Lobes.	Figures.
Central	Lateral	Frontal and Parietal	[illegible]
Sylvian	Lateral	Frontal and Temporal	[illegible]
[illegible]	Lateral	[illegible] and [illegible]	[illegible]
[illegible]	Lateral and ventral	Parietal and Temporal	[illegible]
[illegible]	Lateral	[illegible]	[illegible]
Callosal and the [illegible]	Mesal	[illegible]	[illegible]
[illegible]	Mesal	[illegible]	[illegible]
[illegible]	Ventral	[illegible] and Temporal	[illegible]

§ 188. Prop. CXXIII. *Transitory fissures.*—In the article Development of the Brain (Vol. I., p. 640) these are mentioned, but not distinctly represented in the illustrations; what appear to be transitory corrugations of the thin hemicerebral parietes are shown in Figs. 4756, 4757, and 4758; the first is noteworthy from the fact that the left hemicerebrum (Fig. 4697) of the same fœtus presents no depressions corresponding with 1, 2, 3 on the right. The writer has not yet encountered a brain in which, as stated in the article above named, the temporary fissures have vanished before the permanent ones appear, leaving the surface smooth. The subject is interesting and important, and requires much further observation and study of well-preserved specimens.

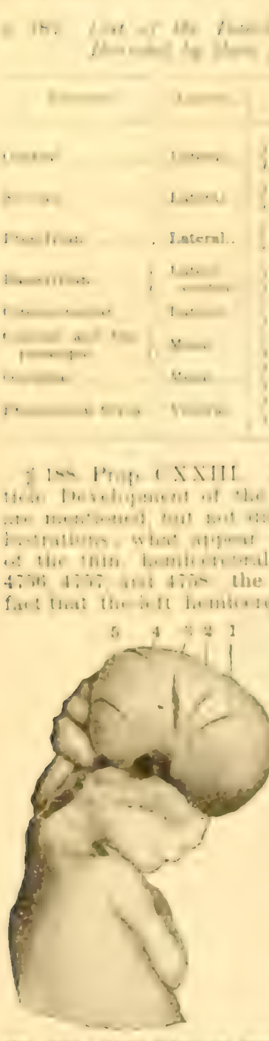

FIG. 4756.—Right Side of the Brain of an Embryo Measuring [illegible] from [illegible] and Estimated at 11 Weeks. [illegible] 1-4 [illegible] in Fig. 4697, [illegible]

§ 189. Points illustrated upon Fig. 4756.—A. The condition and relative size of the encephalic segments at this period; see Fig. 4697.

B. The presence of distinct, lateral fissures which are absent from the other hemicerebrum; notwithstanding their depth, they are probably transitory, at least the three radiating from near the Sylvian fossa.

§ 190. Points illustrated by Fig. 4757.—A. The primary continuity of the hippocampal and callosal fissures, and of the frontal extension marked 1.

B. The existence of several early fissures, some of which are probably transitory.

C. The continuity of the callosum, fornicommissure and terma.

D. The degree of separation of the callosum and the fornix at this period, and the concomitant form and extent of the pseudocœle.

§ 191. Prop. CXXIV. What is perhaps a transient fissure has been observed by the writer to be accurately coincident with the lambdoidal suture in three fœtuses estimated at from three to seven months; see *Journal of Nervous and Mental Disease*, August, 1886.

§ 192. Points illustrated upon Fig. 4758.—A. The distinct collocation of a fissure and suture at this period.

B. The early appearance (or late disappearance?) of

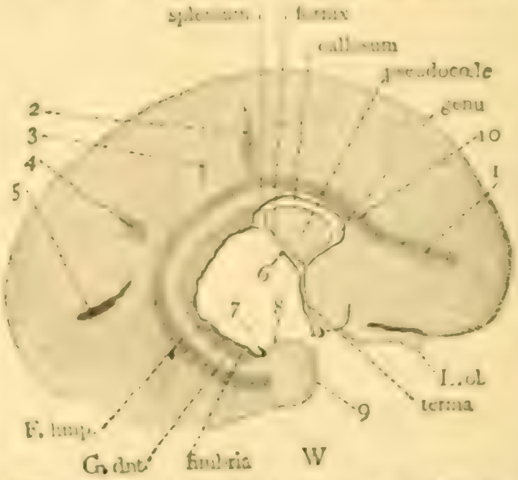

FIG. 4757.—Mesal Aspect of the Left Hemicerebrum of a Fœtus Measuring 16.8 ctm. from Heel to Bregma and Estimated at 18 Weeks. [illegible] 1, [illegible] extension of the primitive callosal fissure; 2, 3, 4, 5, small but distinct radial fissures, some of which probably transitory; 6, point of reflection of the [illegible] from the fornix at the dorsal end of the porta; 7, point of reflection of the endyma at the tip of the [illegible] upon the other margin the [illegible] which has been removed; 8, region which would have become the [illegible]; 9, tip of the temporal lobe; *F. hipp.*, the hippocampal fissure; *G. dnt.*, the dentate gyrus (*fascia* or *fascia dentata*); *L. ol.*, olfactory lobe.

Preparation.—The fœtus was [illegible] and the head [illegible] the entire head was [illegible] the brain was so tender that the [illegible] were broken [illegible]

Defects.—The terma is shown too thick; the [illegible] of the specimen did not permit determining the location and form of the [illegible] and [illegible]

this, the lambdoidal fissure; excepting, perhaps, the dorsal end of the occipital, the rest of this region is smooth.

C. The peculiar sharpness of outline, and the depth of the fissure as compared with its length; both these features reminding one of the supposed transitory fissures (Figs. 4756 and 4757, § 188).

§ 193. Prop. CXXV. The entire ectal surface of the adult hemicerebrum presents alternating depressions, *fissures*, and elevations, gyres (or "convolutions").

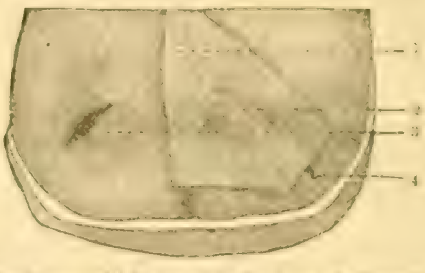

FIG. 4758.—Dorso-caudal Region of the Cerebrum of a Fœtus Measuring [illegible] from Heel to Bregma, and Estimated at Six Months. [illegible] This figure was published by the writer in the *Journal of Nervous and Mental Disease*, August, 1886; see Fig. [illegible] 1, Sagittal suture; 2, lambdoidal suture; 3, right lambdoidal fissure; 4, left [illegible] fissure.

Preparation.—The entire fœtus had been preserved in alcohol. From the left side the [illegible] were removed, excepting a narrow strip along the suture; on the right there was left a trapezoidal area, twelve by twenty-five millimetres, including part of the sagittal and lambdoidal sutures.

The fissures vary in depth from one millimetre to thirty, and in length, from one centimetre to ten. The intervals between the fissures (and thus the width of the gyres) vary greatly, but an adult brain seldom presents an unfissured surface more than 20 millimetres in width.

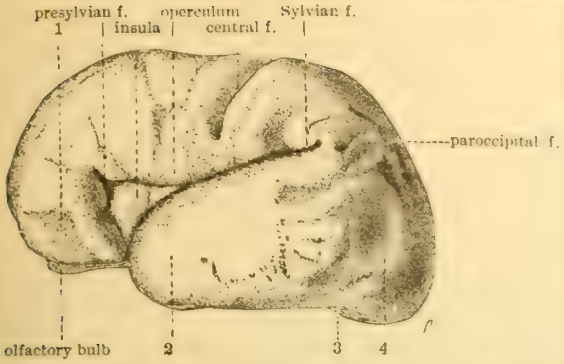

Fig. 4759.—Left Fœtal Hemicerebrum. 1820; × 1. 1, Orbital region, unfissured; 2, temporal lobe, unfissured; 3, slight furrow, the preoccipital fovea; 4, circular depression, unidentified. See § 196.

Preparation.—The fresh hemicerebrum was placed in a mixture of alcohol and glycerine, equal parts; after two days half the mixture was replaced by alcohol; after two days more alcohol alone was used, and renewed on the following day. The original mixture seemed to prevent the usual distortion of fœtal brains, and to facilitate the removal of the pia. Unfortunately the age and size of the fœtus were not recorded.

Notwithstanding considerable variations in different brains, and in different parts of the same brain, one can hardly fail to be impressed with the approximate uniformity of the interfissural spaces (when viewed squarely, as suggested under Fig. 4771) as if the fissures were produced mechanically by the extension of the surface within a confined space; see also the writer's observation upon the fissures of dogs, *Amer. Assoc. Proc.*, 1873, p. 248.

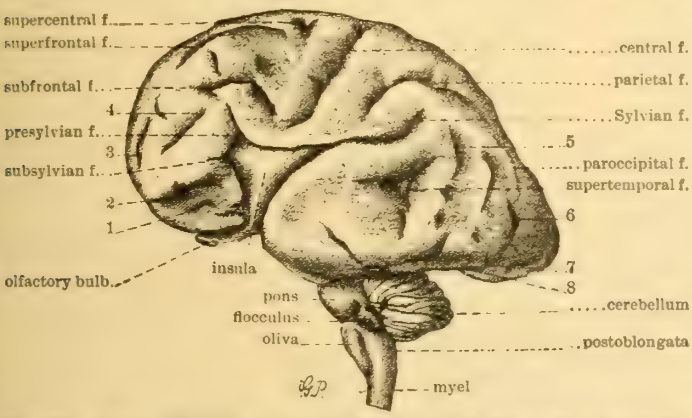

Fig. 4760.—Lateral Aspect of the Left Half of the Brain of a Fœtus, Size and Age Unknown. 2278; × 1. 1–8, Fissures not identified with certainty. See § 197.

Preparation.—The brain was medisected while fresh and this half placed in alcohol upon its mesal aspect; it has become thinner and wider than natural, but exhibits the fissures more perfectly on this account.

§ 194. Prop. CXXVI. Fissures should be studied before gyres, because: 1, They are simpler, being represented by lines instead of planes; 2, they are more commonly entirely independent of other fissures; 3, they are comparable with the rivers of a region which are employed as boundaries of the subdivisions; 4, themselves structureless, they really represent the locations of a greater amount of cinerea than lines of equal width and extent on the gyres, and have thus a greater, presumptive, physiological significance, although there seems to be a difference of opinion as to the functions of the intrafissural cinerea.

§ 195. Prop. CXXVII. For the elucidation of the intricacies of adult fissures, *fœtal brains are much more serviceable than those of monkeys.* This, in contravention of the view and practice of Meynert (*Psychiatry*, p. 7), was insisted upon by the writer (*Amer. Assoc. Proc.*, 1886), and *American Naturalist*, Oct., 1886, p. 902). Some of the peculiarities and complexities of the monkey brain are represented in Fig. 4788.

§ 196. Points illustrated by Fig. 4759.—A. The early appearance of the Sylvian, presylvian and central fissures, and of a depression which was to become the paroccipital. See the ventral surface of this specimen (Fig. 4782).

B. The nearly uncovered and slightly fissured condition of the insula at this period; the faint dorso-ventral line just caudad of the end of the line from *insula* represents the just commencing transinsular fissure, seen distinctly in Fig. 4715.

§ 197. Points illustrated upon Fig. 4760.—A. The condition of the insula and operculums at this stage. The former is distinctly elevated, but as yet perfectly smooth, while in the otherwise less advanced brain shown in Fig. 4759 it has a slight transinsular furrow. The subsylvian fissure is just forming as the ventral boundary of the preoperculum.

B. The demarcation of the subfrontal gyre by the subfrontal fissure.

C. The non-continuity of the parietal and paroccipital fissures.

D. The non-appearance of the precentral and postcentral fissures.

E. The peculiar triangular depression which seems to represent the commencement of the supertemporal fissure.

F. The presence of three fissures or series of fissures caudad of the supertemporal, the middle of which may represent the exoccipital (§ 274).

G. The interruption of the central fissure near its dorsal end; so much as appears in the figure is continuous, but near the mesal margin of the hemicerebrum is a slight depression separated from the longer lateral portion by an isthmus; this condition in the fœtus is noteworthy in view of Heschl's observations (§ 246).

H. The small size of the cerebellum, the freedom of the flocculus therefrom, and the prominence of the oliva.

§ 198. Points illustrated by Fig. 4761.—A. The existence of three independent furrows between the callosum and the margin of the hemicerebrum along the line of what is commonly called the calloso-marginal fissure.

B. The distinctness at this period of the four total or collicular fissures, occipital, calcarine, collateral, and hippocampal.

C. The independence of the occipital and calcarine.

D. The extension of the calcarine alone nearly or quite as far as the point reached in some other brains by the occipital alone or by the compound fissure, occalcarine (§ 214, G).

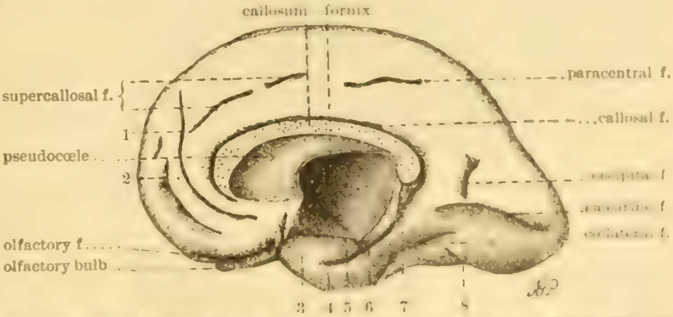

Fig. 4761.—Mesal Aspect of the Left (Reversed) Hemicerebrum of a Fœtus, Size and Age Unknown. 2278; × 1. The lateral aspect of the left half of the same brain is shown in Fig. 4760. 1, 2, 8, Undetermined fissures; 3, tip of temporal lobe; 4, ventral end of hippocampal fissure; 5, uncus; 6 (should have been extended a little farther so as to reach the light band), fimbria; 7, dentate gyre (*fascia dentata*).

§ 199. Plate CXXVIII. *Total and partial fissures.*—Of the permanent fissures some affect merely the cortex and the adjacent white and are therefore sometimes called partial fissures; the central, for example, though constant and deep, is only a partial fissure. But others represent corrugations of the entire parietes so that the ectal depression, fissure, is opposite and obviously correlated with an ental elevation, colliculus; the fissures commonly enumerated as total are the hippocampal (Fig. 4760), calcarine (Fig. 4763), and collateral (Fig. 4764); the Sylvian may be correlated with the caudatum (Fig. 4769); the [illegible] and occipital are total fissures in the fœtus (Figs. 4758 and 4763), and the ental correlative of the latter is sometimes recognizable in the adult (Fig. 4760).

§ 200. Plate CXXIX. *Classification of the permanent fissures.*—The following grouping of the fissures is approximately natural and has been found convenient by the writer; at the best, however, any such arrangements are provisional.*

A. Total fissures, representing a corrugation of the entire paracœlian parietes; *e.g.*, calcarine.

B. Partial fissures with some structural correlative; *e.g.*, olfactory.

C. Partial fissures nearly or quite constant and demarcating recognized gyres; *e.g.*, central.

D. Inconstant, intragyral fissures; *e.g.*, medifrontal.

§ 201. *A List of the Total Fissures with their Ental Correlatives (Colliculi), and the Figures Exhibiting the Conditions.*

Fissures.	Colliculi.	Figures.
1 Calcarine	Calcar	4758, 4762, 4763
2 Occipital	Occipital eminence (in the fœtus only)	4758, 4763
3 Collateral	Collateral eminence	4764, 4765
4 Hippocampal	Hippocamp	4757, 4761, 4763, 4765, 4762, 4767, 4768
5 Callosal	[illegible] (in the fœtus, presumably absent in the adult)	4758, 4759, 4762, 4765, 4766
6 Sylvian	Caudatum (?)	4769

§ 202. Points illustrated by Fig. 4762.—A. An early stage in the formation of the Sylvian fissure, the presylvian fissure being represented by a mere notch.

B. The incomplete separation of the calcar and the occipital eminence.

C. The size of the postcornu relatively to that of the entire hemicerebrum.

§ 203. Points illustrated by Fig. 4764, in addition to A and B, specified under Fig. 4749, § 169.—A. The contiguity of the two margins of the rima excepting for the intruded paraplexus.

B. The consequent absolute exclusion of the ental space from the [illegible].

C. The depth and peculiar form of the hippocampal fissure (Fig. 4768).

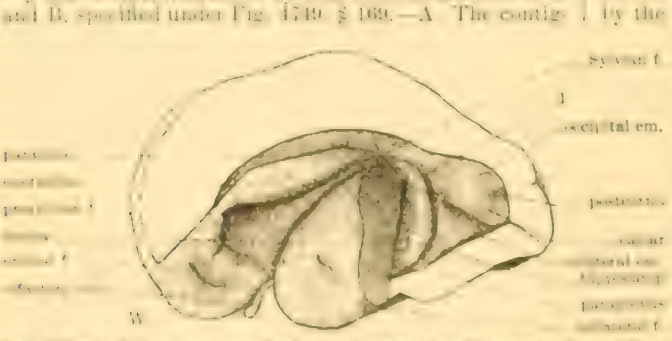

Fig. 4762.—Left Hemicerebrum of a Fœtus [illegible]. Opened from the mesal aspect. [illegible]

D. The corrugation constituting the collicular calcar and calcarine fissure.

E. The equally distinct corrugation of the occipital fissure, at this period with the adjoining collateral occipital eminence, sometimes called "bulb of the posterior cornu."

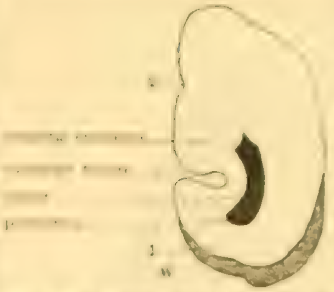

Fig. 4763.—Transection of the Left Occipital Lobe of a Fœtus [illegible] × 1.5. The fissure is [illegible] represented as in Fig. 4763 A.

§ 204. Points illustrated in Fig. 4765.—A. The mesal wall of the postcornu presents a ridge, the calcar, and the mesal surface of the occipital lobe a furrow, the calcarine fissure; as seen in Figs. 4763 and 4764, the ental depression and the ectal elevation are obviously correlated.

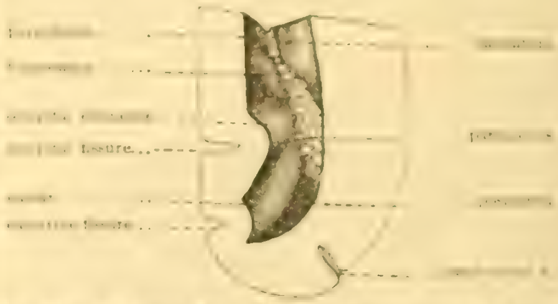

Fig. 4764.—The Caudal Part of the Right Hemicerebrum of a Fœtus Measuring 14 cm., from Vertex to Coccyx, and Hardened in a Mixture 1876. × 1.5. See § 203.

Preparation.—This is part of the specimen shown in Fig. 4749, where the mode of preparation is described; the postcornu was exposed by removing the parietes [illegible]. The plexus was partly cut away [illegible].

B. The precornu presents an ental elevation, the caudatum, and a depression nearly opposite, the Sylvian fissure; but the correlation of the two is not quite clear and the conditions are complicated by the formation of the intrafissural (or intergyral) elevation called insula.

C. Here as in the postcornu there is no doubt respecting the correlation of the ental elevation or colliculus, the hippocamp and the ectal furrow, the hippocampal fissure. In addition, the proper nervous parietes are interrupted along a line, the rima, and the paraplexus is formed by the intrusion of the pial process covered by the endyma; the margins of the rima are specialized and become the fimbria and tænia (on the figure the tænia is not indicated as separate from the caudatum), see § 154.

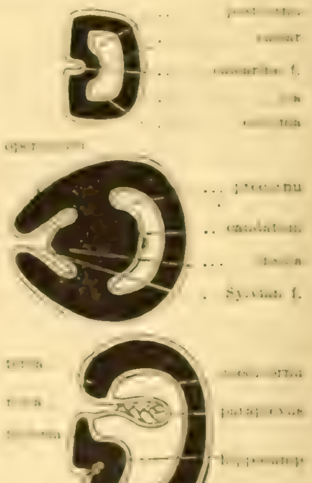

Fig. 4765.—Schematic Transections of the Three Cornua [illegible].

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* [illegible]

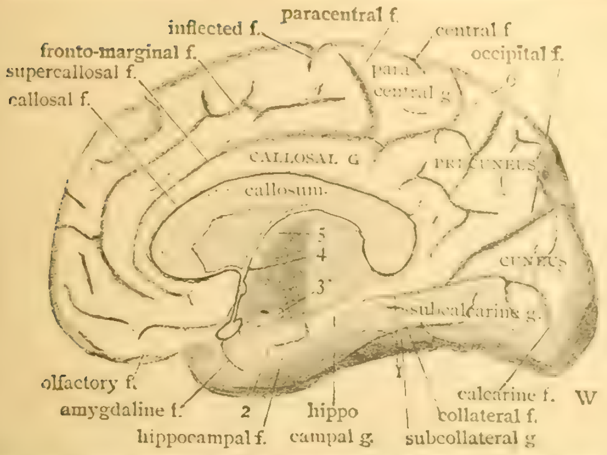

Fig. 4766.—Mesal Aspect of the Left (reversed so as to appear the right) Hemicerebrum of an Adult Male Mulatto. 322; .5. 1, Occalcarine fissure, the common stem of the occipital and calcarine; 2, uncus; 3, optic tract, divided obliquely; 4, fornicommissure; 5, retreating ventral surface of the fornix; 6, paracentral fissure. See § 207.

Preparation.—The entire brain was hardened by continuous alinjection while in the cranium: this and all the other views of it (Figs. 4767, 4770, 4777, 4786, and 4787) are based upon photographs.

Defects.—Most of the fissure lines are too faint: the emargination of the ventral outline just cephalad of the optic nerve is too decided.

§ 205. Prop. CXXX. With children born at term the main fissures are always well defined, and in some cases there seems to be little difference between infant and adult cerebrums in respect to fissural complexity, although the insula is always less developed and less completely covered by the operculums (see Figs. 4715 and 4776). Such brains are often more readily obtained and removed than those of adults and if well preserved and carefully handled may materially aid both study and investigation (see Figs. 4774 and 4776).

§ 206. Prop. CXXXI. Adult cerebrums commonly present individual peculiarities which prevent their serving as types or standards; the writer has found such in every brain examined; even that of a mulatto, simple in several respects, has peculiarities and complexities not as yet fully understood (see Figs. 4766, 4767, 4778, and 4779).

§ 207. Points illustrated upon Fig. 4766.—A. The form of this adult mulatto brain, unaltered save by shrinkage.

B. The continuity of the supercallosal and paracentral fissures.

C. The extent of the fronto-marginal fissure.

D. The complexity of the precuneal fissure.

E. The length of the collateral fissure.

F. The invisibility of the hippocampal fissure excepting at its dorsal end, where it is continuous with the callosal around the splenium, and at its ventral end where it lies between the uncus and the main part of the hippocampal gyre. The margin of this gyre between the tip of the uncus and the splenium is sometimes regarded as one side of the hippocampal fissure, but this is not strictly correct, any more than it would be to regard the crest of a hill as one of the walls of a ravine in its farther slope.

G. The appearance of the dorsal end of the central fissure, dorsad of the splenium.

H. The distinctness of the amygdaline fissure.

I. The sharp ventral deflection of the calcarine fissure, which passes across the margin so as to appear upon the lateral aspect (Figs. 4767 and 4786).

§ 208. Points illustrated upon Fig. 4767.—A. The form of this adult, mulatto, left hemicerebrum, unaltered save from alcoholic shrinkage.

B. A simple, almost typical condition of certain fissures, *e.g.*, central and Sylvian, in a large part of their course, combined with great and unusual peculiarities of the same or other fissures.

C. The visibility of the insula; see Figs. 4778 and 4779.

D. The separation of the preoperculum from the postoperculum by the confluence of the proximal parts of the pre- and subsylvian fissures.

E. The union of the subfrontal fissure, deeply with the

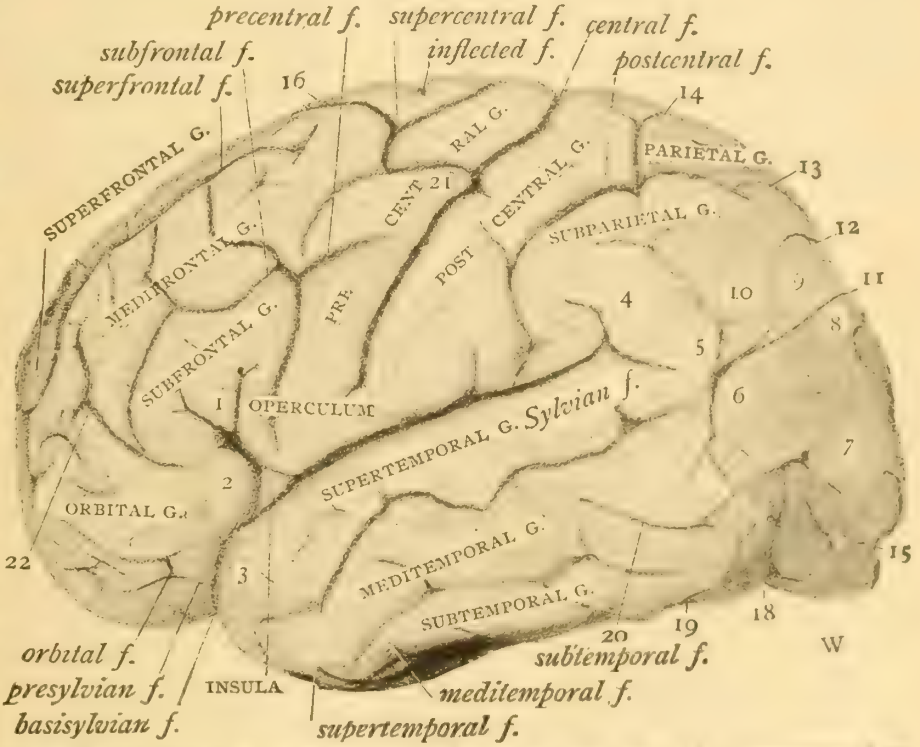

Fig. 4767.—Lateral Aspect of the Left Hemicerebrum of a Mulatto (Fig. 4766). 322; .8. 1, Preoperculum; 2, suboperculum, 3, postoperculum; 4, what is commonly called the "supramarginal gyre;" 5, may represent part of what is called the "angular gyre;" 6, a supergyre overlapping the concealed caudal part of the [illegible] occipital gyre; 8, 9, portions of the unidentified supergyre that overlaps the lateral part of the [illegible] gyre; 10, gyre at the caudal (apparently dorsal) side of the dorsal, deflected end of the supertemporal [illegible] dorsal end of the occipital fissure (this is, however, invisible, and the straight fissure that [illegible] between 8 and 9, and curves ventrad at 6, may probably be the exoccipital or Wernicke's [illegible] "ape-fissures;" it has apparent, though not real, connections with the occipital and [illegible]. 12, curved fissure in the same supergyre, superficially connected with the supertemporal. 13, [illegible] cipital fissure; 14, dorsal fork of the postcentral fissure; 15, caudal extremity of the [illegible] independent; 16, cephalic radius of the triradiate supercentral fissure, see Fig. 4772; 18, 19, 20, [illegible] temporal fissures; 21, just ventrad of the strait between the central and [illegible] (see Figs. 4771 and 4777); 22, the most cephalic of three distinct fissures crossing the medifrontal gyre.

presylvian and the three transfrontal fissures, the most cephalic of which is marked 24, and superficially with the short fissure connecting the precentral with the supercentral.

F. The apparent narrowness of the superfrontal gyre, which nevertheless, as seen from the dorsal aspect, is of considerable width; in fact the narrowest portion of the superfrontal is just as wide as is the subfrontal measured in line with the stem of the compound presylvian and subsylvian fissures; this is a forcible exemplification of what is expressed under Figs. 4771 and 4772.

G. The great length of the supertemporal fissure, and its apparent dorsal branching in four directions; its true and deep continuation is explained between 5 and 10.

H. The continuation of the calcarine fissure around the margin of the hemicerebrum so as to appear upon the caudo-lateral aspect as an undivided end.

I. The superficial connection of the central and precentral fissures.

J. The partial appearance of the subtemporal fissure on the lateral aspect; see, however, Figs. 4767 and 4770.

K. The forking of the Sylvian into an episylvian fissure, next 4, and a hyposylvian, next 5.

§ 209. *List of the Partial Fissures with Structural Correlatives.*

Fissures.	Correlatives.	Figures.
1. Central	[illegible]	[illegible]
2. [illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]
4. [illegible]	[illegible]	[illegible]
5. [illegible]*	[illegible]	[illegible]
6. [illegible]	[illegible]	[illegible]

§ 210. *List of Partial Fissures, Constant or Nearly So, and Demarcating Gyres but with no Structural Correlatives* (*Figs.* 4768 *and* 4769).

Fissures.	Rank.	Gyres demarcated by them.	Figures.
1. Basisylvian ...	[illegible]	[illegible]	[illegible]
2. [illegible]	[illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]	[illegible]
4. Insular	[illegible]	[illegible]	[illegible]
5. [illegible]	[illegible]	[illegible]	[illegible]
6. [illegible]	[illegible]	[illegible]	[illegible]
7. [illegible]	[illegible]	[illegible]	[illegible]
8. [illegible]	[illegible]	[illegible]	[illegible]
9. [illegible]	[illegible]	[illegible]	[illegible]
10. [illegible]	[illegible]	[illegible]	[illegible]
11. [illegible]	[illegible]	[illegible]	[illegible]
12. [illegible]	[illegible]	[illegible]	[illegible]
13. [illegible]	[illegible]	[illegible]	[illegible]
14. [illegible]	[illegible]	[illegible]	[illegible]
15. [illegible]	[illegible]	[illegible]	[illegible]
16. [illegible]	[illegible]	[illegible]	[illegible]
17. [illegible]	[illegible]	[illegible]	[illegible]
18. [illegible]	[illegible]	[illegible]	[illegible]
19. [illegible]	[illegible]	[illegible]	[illegible]

§ 211. *List of Inconstant Fissures, with the Gyres in which They Occur* (*Figs.* 4768 *and* 4769).

Fissures.	Gyres.	Figures.
1. [illegible]	[illegible]	
2. [illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]
4. [illegible]	[illegible]	[illegible]
5. [illegible]	[illegible]	[illegible]
6. [illegible]	[illegible]	[illegible]
7. [illegible]	[illegible]	[illegible]
8. [illegible]	[illegible]	[illegible]
9. [illegible]	[illegible]	[illegible]
10. [illegible]	[illegible] (?)	[illegible]
11. [illegible]	[illegible] (?)	
12. [illegible]	[illegible]	
13. [illegible]	[illegible]	[illegible]
14. [illegible]	[illegible]	
15. [illegible]	[illegible]	
16. [illegible]	[illegible]*	
17. [illegible]	[illegible] (?)	
18. [illegible]	[illegible] and [illegible]	[illegible]
19. [illegible]	[illegible]	[illegible]

§ 212. Prop. CXXXII. The study of fissures upon actual brains is facilitated by reference to diagrams such as have been published by Pansch, Jensen, Ecker, and others;† the present views of the writer are embodied in Figs. 4768 and 4769.

§ 213. Comments upon the fissural diagrams (Figs. 4768 and 4769).—A. They represent the writer's views at this time, but are not identical with those published by him three years ago (*American Naturalist*, October, 1886), and are subject to further modification with increasing knowledge of the facts. For example, the small fissures caudad of the occipital are but little understood, and the [illegible] frontal of Giacomini may prove to be more nearly constant than now supposed.

B. The diagrams are warranted, in most respects, by the brains herein figured, although these constitute but a small portion of the material employed.

C. An attempt has been made to indicate the relative depth and constancy of the fissures by lines of three degrees of width; this grouping, however, is provisional.

D. Excepting with the orbital, paroccipital, and precuneal, the fissural lines are unbranched, and without contortions.

E. As a rule, two lines are connected only when the fissures they represent are always, or almost invariably, continuous in the adult.

F. These connections are of two distinct kinds: primary, invariable, and inevitable from the mode of formation of the parts; secondary, and more or less common, but not necessary.

G. *Invariable* and apparently inevitable fissural connections are (1) of the Sylvian with the basisylvian, presylvian, and subsylvian, all which might be regarded as its continuations or branches; (2) of the callosal with the hippocampal.

H. *Usual* connections are of the occipital with the calcarine, and of the supercallosal with the paracentral, but there are occasional exceptions.

I. *Common* connections are of the superfrontal and supercentral; the precentral and subfrontal; the precentral and supercentral; the postcentral and parietal; the parietal and paroccipital.

J. *Occasional* connections are of the precentral with the Sylvian, and of the central with the Sylvian over the margin of the operculum; in these cases, so far as known to the writer, the junction is seldom very deep.

§ 214. From the deservedly popular fissural diagrams of Ecker, the publication of which has so materially advanced the general knowledge of the subject, these differ mainly in the following respects:

A. The omission of branches and corrugations.

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* [illegible] (see § 211.)

* Observed on both sides of the brain of an insane woman, No. 2268, Museum of Cornell University, and on the right of No. [illegible].

† The writer regrets that the [illegible] papers by Dr. C. L. Dana ("[illegible]," New York Medical Record, January 12, 1889, pp. 29–34, 18 illustrations) did not appear in time for his suggestions to be considered in this connection.

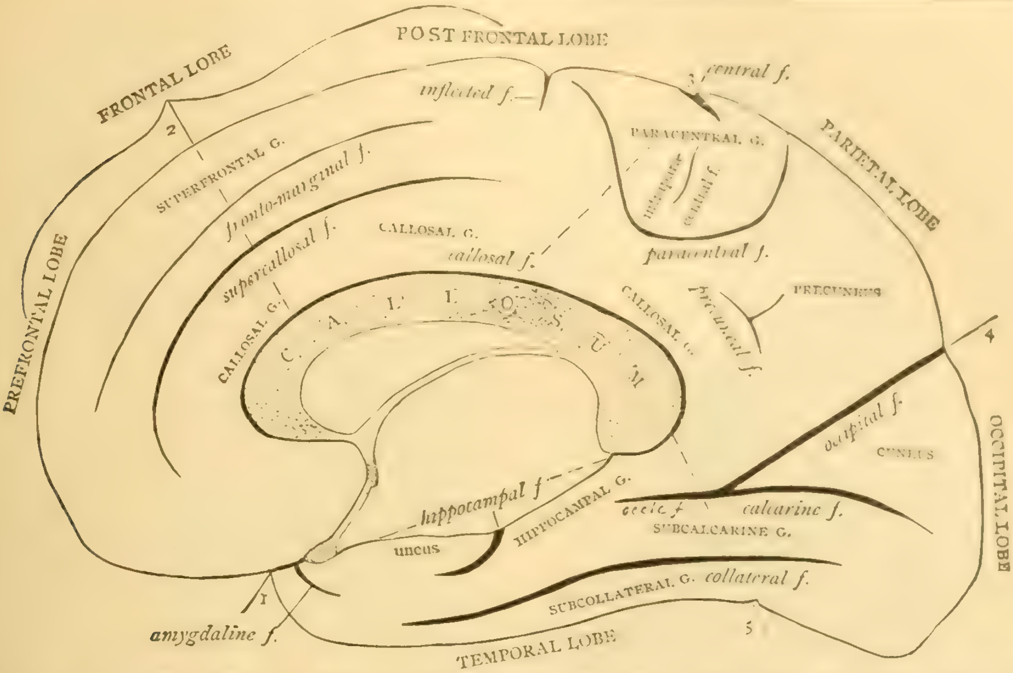

FIG. 4768.—Diagram, nearly Natural Size, of the Fissures upon the Mesal Aspect. The outline and the locations of the principal fissures are from the mulatto brain, represented in Fig. 4766, which was hardened within the cranium. The numbers 1-5, designate the five interlobar lines or boundaries, as follows: 1, fronto-temporal; 2, inter-frontal; 3, fronto-parietal; 4, parieto-occipital; 5, occipito temporal. The abbreviation *occic. f.* stands for occalcarine fissure, the stem or confluence of the occipital and calcarine fissures.

B. The inclusion of the callosal, inflected, amygdaline, medifrontal, precuneal, and subtemporal fissures.

C. The disjunction of the supercallosal from the paracentral.

D. The separation of the precentral from the subfrontal.

E. The introduction of the exoccipital as probably representing the true "ape-fissure" of Wernicke.

F. The combination of the "transverse occipital" of Ecker with the caudal portion of his "interparietal" as a distinct fissural integer, the paroccipital.

G. The designation of the apparently common stem of the occipital and calcarine as the *occalcarine*.

H. The adoption from various writers of what seem to be the best fissural names of a single word each; *e.g.*,

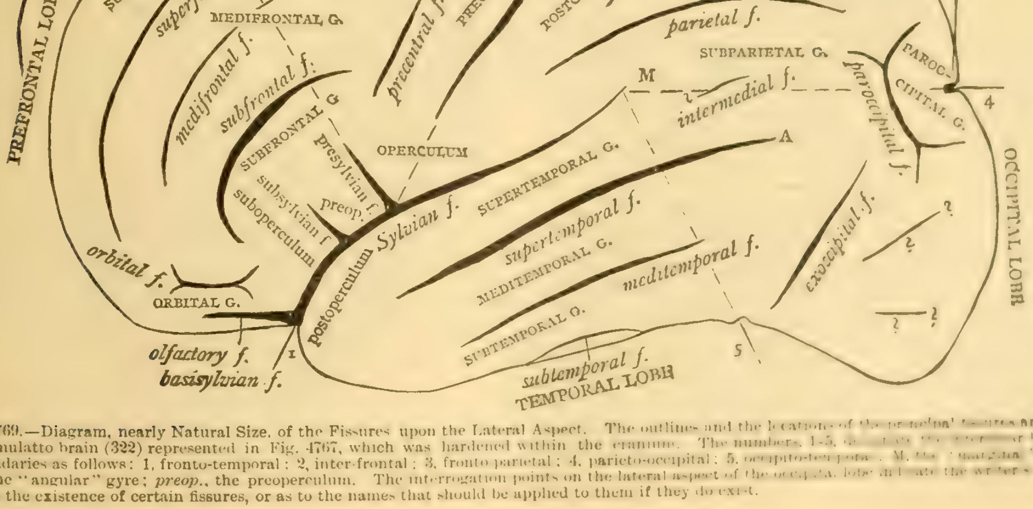

FIG. 4769.—Diagram, nearly Natural Size, of the Fissures upon the Lateral Aspect. The outlines and the locations of the principal fissures are from the mulatto brain (322) represented in Fig. 4767, which was hardened within the cranium. The numbers 1-5, designate the five interlobar lines or boundaries as follows: 1, fronto-temporal; 2, inter-frontal; 3, fronto-parietal; 4, parieto-occipital; 5, occipito-temporal. M, the [illegible] gyre; A, the "angular" gyre; *preop.*, the preoperculum. The interrogation points on the lateral aspect of the occipital lobe indicate the writer's doubts as to the existence of certain fissures, or as to the names that should be applied to them if they do exist.

from Huxley, *subcentral*; from Owen, *callosal*, [illegible] and [illegible]; from Wernicke, *frontomarginal*; from Jensen, *intermedial*; from Pansch, [illegible] and [illegible]; from Schwalbe, [illegible] and [illegible]; from Meynert, [illegible].

J. The substitution of [illegible] mononyms for polyonyms, viz., [illegible] for ascending branch of the [illegible]; [illegible] for anterior branch; [illegible] for the part ventral of the [illegible]; and the restriction of [illegible] to the [illegible] posterior branch.

J. The explanation of *lingual lobule* and *fusiform lobule* [illegible] to apply correctly [illegible] gyri and [illegible] gyri [illegible] at once associated with the fissures which respectively constitute the dorsal boundaries.

K. The use of one and the same word, *fissure*, for all the cerebral depressions excepting the two fossæ.

L. The use of one and the same word, *gyre*, for all subdivisions of the lobes, excepting the cuneus and precuneus, already well distinguished by mononyms.

§ 218. Points illustrated by Fig. 1770.—A. The relative length and width of a hemicerebrum, unaltered excepting from alcoholic shrinkage.

B. The presence of a distinct though rounded prominence between the frontal and the lateral portions of the outline, but the absence of any such boundary between the lateral outline and the occipital (see Fig. 1768).

C. The narrowness of the olfactory gyre between the fissure of that name and the mesal margin of the frontal lobe.

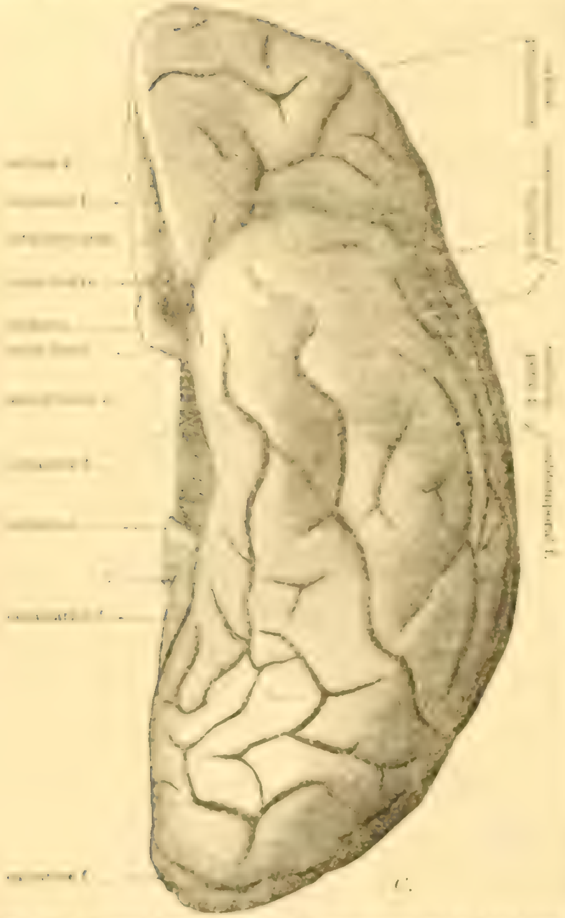

FIG. 1770.—Ventral Aspect of the Left Hemicerebrum of an Adult Male Mulatto. [illegible]

[illegible]

FIG. 1771.—[illegible]

D. The distinctly zygal form of the orbital fissure.

E. The length and distinctness of the subtemporal fissure.

F. The extension of the calcarine fissure upon the occipital end of the hemicerebrum.

G. The presence of a fissure [illegible] on the mesal surface, caudad of the [illegible] fissure.

§ 219. Points illustrated upon Fig. 1772.—A. The length and independence of the superfrontal fissure, and its close parallelism with the dorsal cerebral margin.

B. The extent of the [illegible] fissure upon the dorsal surface, outlining, with the two dorsal radii of the supercentral, a U-shaped area (resembling the sigmoid gyre about the cruciate fissure in the cat, Fig. 1698) which might, if sufficiently constant, be called the *sigmoid* gyre.

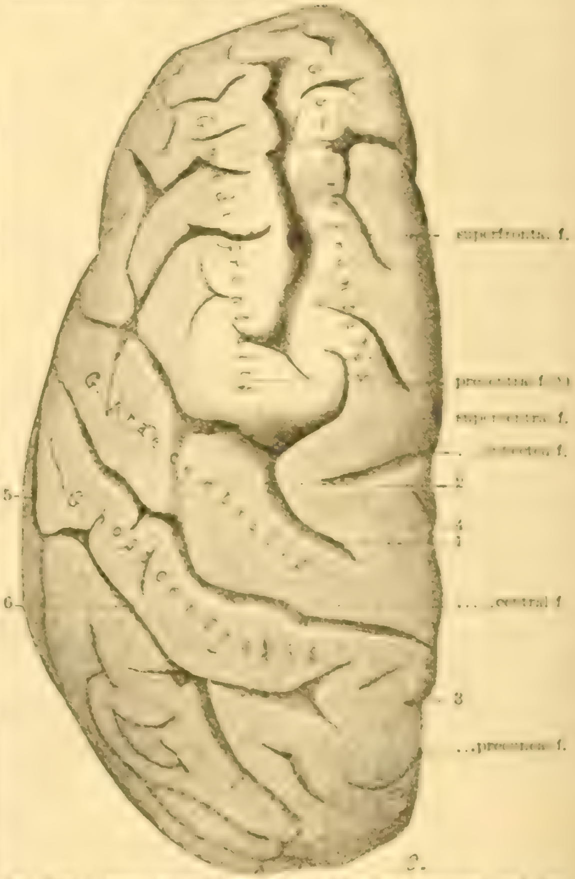

FIG. 1772.—Dorso-cephalic Aspect of the Left Hemicerebrum of a Mulatto. [illegible] 4, cephalic end of the [illegible]

C. The apparently deep communication of the central with the supercentral fissure at 2; at about the middle of this strait, however, is a distinct vadum, a shallow not more than 2 mm. below the surface, and visible in an oblique view, as in Fig. 4777.

D. The triradiate form of the supercentral fissure; one of its dorsal radii is marked (1); the ventral is apparently continuous with the precentral, but the fissure so named is shallow at each end, as stated under Fig. 4767.

E. The continuity of the postcentral fissure with the parietal, which would be reached by the extension of the line from 3.

F. The width of the superfrontal gyre when thus viewed directly, as compared with its apparent width when seen obliquely as in Fig. 4767; see Fig. 4771.

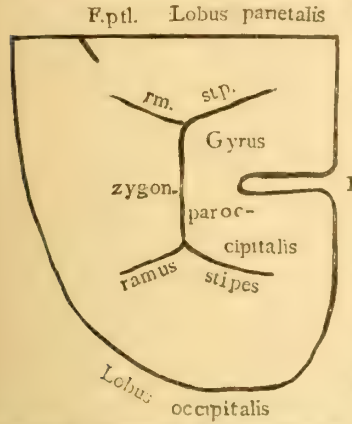

FIG. 4773.—Diagram of the Paroccipital as a Type of the Zygal Fissures (originally published in the *Journal of Nervous and Mental Disease*, June, 1886). The figure represents the dorso-caudal aspect of the occipital end of the left hemicerebrum, including the occipital lobe and part of the parietal, with the dorsal end of the occipital fissure (*F. oc.*) and the caudal end of the parietal (*F. ptl.*). The H-shaped line represents the paroccipital fissure, bounding the gyre of the same name. The bar of the H constitutes the zygon, or yoke, connecting the diverging branches at either end; from the mode of formation the mesal branch is the *stipe* or *stem* (Lat., *stipes*) and the lateral, the *ramus*.

§ 217. Prop. CXXXIII. *Fissural Integer.*—This term (introduced by the writer in 1886, *Jour. of Nerv. and Mental Disease*, xiii., No. 6) is employed herein to designate a fissure which is independent in some species or individuals, and deepest at or about the middle of its length, corresponding nearly with the place of its first appearance. Any marked and frequent shallowing of a supposed fissural integer is reason for questioning its integrality, and for seeking, in other individuals and in allied species, evidence that it really consists of two.

For a summary of the fissural connections observed by the writer, see § 213, F–J. Constant and apparently inevitable branches (*e.g.*, the presylvian and subsylvian) are not strictly integers, although conveniently treated as such. The doubts respecting the central fissure are mentioned in § 253; the relations of fissural integers, as above defined, to more extensive lines of depression which are ideally continuous or may be actually so in some animals (*e.g.*, the alleged components of Meynert's "arched fissures," and of Broca's "limbic lobe" outline, and of the feline anterior and postica fissures in respect to the ventral arched fissure of the fox [see "Anat. Technology," § 1354]) cannot be considered here.

§ 218. Prop. CXXXIV. The "interparietal fissure" of Ecker probably represents two fissural integers, the parietal and the paroccipital, because (1) in about half the cases examined by the writer there are two fissures separated by an isthmus of greater or less width; (2) when the two were continuous there was almost always a vadum at the point corresponding to the isthmus; (3) each of the two portions, whether separate or continuous, is usually deepest at or near its middle; (4) at their first appearance in the fœtus they are always completely independent.*

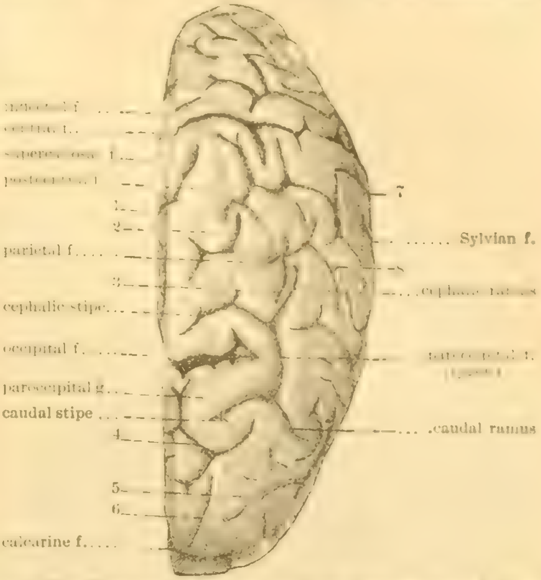

FIG. 4774.—Dorso-caudal Aspect of the Right Hemicerebrum of a Child at Birth. 478; × 1. This figure was published in the *Journal of Nervous and Mental Disease*, June, 1886. Other aspects of the same brain are shown in Figs. 4715, 4718, and 4776.

§ 219. Points illustrated upon Fig. 4774.—A. The form of a perfect and typical paroccipital fissure, very symmetrical, and completely independent of the parietal, although its cephalic ramus and what seems to be an extension of the parietal overlap and approach very closely.

B. The peculiar appearance of the entire hemicerebrum and of the central fissure from this point of view.

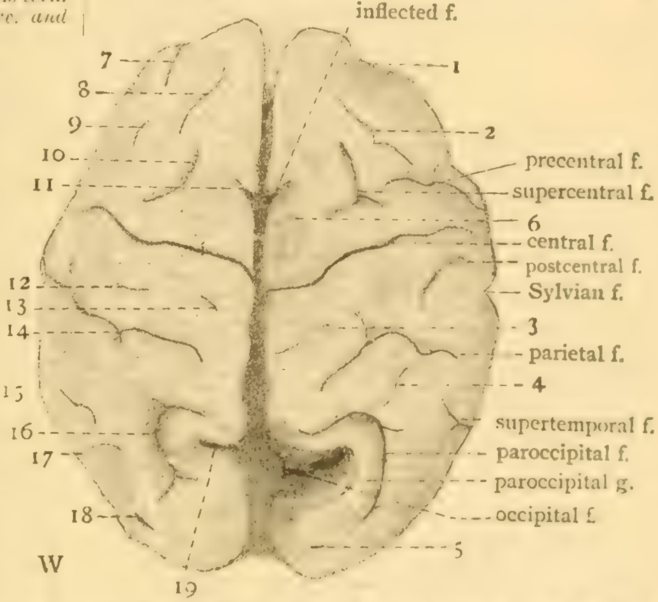

FIG. 4775. Dorso-caudal Aspect of the Brain of a Fœtus, Measuring 41 ctm. from Heel to Bregma, and Estimated at 8 Months. 734; × 1. 11. Left inflected f.; 12, 13, separate portions of the left postcentral (?); 14, left parietal (?); 16, left paroccipital; 17, left supertemporal; 18 (and 5 ?) the lambdoidal fissures; 19, left occipital f. The remaining numbers indicate fissures of doubtful identity. See § 220.

Preparation.—The arteries were injected with starch mixture; extravasation took place at several points, especially the two following: (1) into the dorsal part of the right occipital fissure, converting it into a kind of fossa at the bottom of which is seen the unaffected part of the fissure; (2) into the left paroccipital fissure, separating its walls to some extent. The essential relations of parts are [illegible].

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* The propriety of dividing the "interparietal" is conceded by Dana, on p. 34 of the *New York Medical Record*, January 12, 1889.

§ 220. Points illustrated upon Fig. 4775.—A. The degree of fissuration at this period.

B. The early condition of the paroccipital fissure as a [illegible] depressed line with lateral branches.

C. The independence of the paroccipital fissure at this period.

D. The absence of any fissure closely resembling the "transverse occipital."

E. The presence of a short fissure, the [illegible] near the caudal end of each hemicerebrum [illegible]

F. The distribution of the inflected fissures at this period.

G. The difficulties of identifying fetal fissures in the [illegible] of those upon the frontal and parietal regions of this specimen.

§ 221. The point illustrated upon Fig. 4776, in addition to some equally well exhibited upon Figs. 4715 and 4774, is the greater depth of the paroccipital zygon at the middle of its length, a fact hardly compatible with the supposition that it is only a caudal extension of the parietal, or that the caudal stipe and ramus constitute an independent fissure, the "transverse occipital" of Ecker.

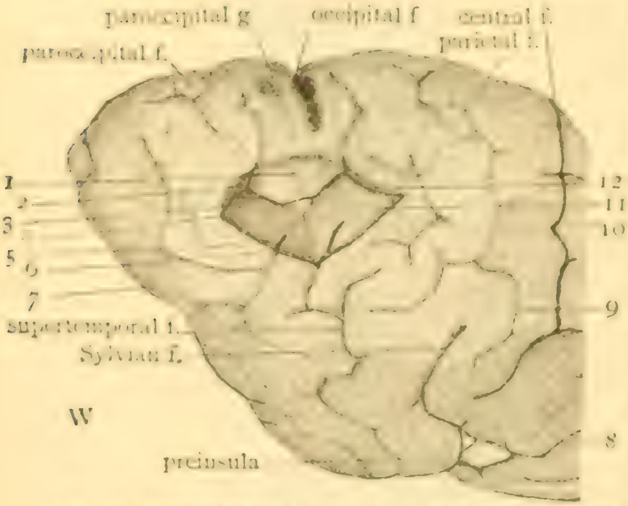

FIG. 4776.—Dorso-caudo-lateral Aspect of the Right Hemicerebrum of a [illegible] 478; × 1. [illegible] rami. [illegible]

§ 222. Prop. CXXXV.—A cerebral fissure is a narrow space vacant of brain tissue and containing only a fold of pia with blood-vessels; yet it has many and sometimes important relations, a complete account of which would embrace between thirty and forty distinct topics. Every fissure demands monographic treatment, but the limits of this article permit only one to be discussed with even approximate completeness, although another, the paroccipital, has been briefly considered (§ 217) in illustrating certain difficulties of fissural study.

§ 223. Prop. CXXXVI.—Pre-eminent importance of the central fissure.—Taking all things into account, the central fissure demands first and fullest consideration; there is indeed no fact concerning it that is not worth recording or that may not prove significant morphologically or practically valuable. The order in which the following topics are presented is far from perfect, but it may serve to indicate the many relations of these cerebral features. To save space the pronoun *it* will commonly designate the central fissure.

§ 224. The name.—It has been called, to use the Latin forms, *fissura*, *sulcus*, and *rima*, with the qualifying adjectives *centralis*, *Rolandica* and [illegible], all these having of course appropriate equivalents in the various modern languages. The writer's doubts as to the utility of discriminating at present between fissures and sulci, have been expressed in § 200, note. His reasons for preferring *central* to *Rolandic* are given in the article Anatomical Terminology.

§ 225. General location and direction.—On the dorso-lateral aspect of the cerebrum at about the middle of its length; from a point at or near the dorsimesal margin, it extends latero-cephalad at an angle of about 67 degrees with the meson, or about 134 degrees with its opposite.*

§ 226. Dimensions.—Among adult hemicerebrums in the museum of Cornell University the length of the fissure, measured in a straight line between the two ends, varies from 8 to 10.5 cm., the usual length being about 9.5 cm., or about one-fourth of the entire circumference of a cerebrum as measured in a dorso-ventral plane intersecting the fissure at about the middle of its length. If measured along the sinuosities, as if the fissure were straightened out, the length may be one-seventh greater than if measured across the curves. The greatest depth varies from 10 to 15 millimetres.

§ 227. Relation to cranial elevations.—There is no evidence of any special collocation between it and any cranial elevation in man or any other mammal; hence, though so deep, it is not a total but a partial fissure (§ 200, A).

§ 228. Constancy.—There is known to the writer no case of the absence of the central fissure in an adult or after the sixth month of fetal life.

§ 229. Topographical importance.—This is well indicated in the following vigorous declarations of Wagner and Ecker: "*Man muss sie immer zuerst aufsuchen, um sich von da in dem schwierigen Chaos der Hirnwindungen* . . . ." " . . . *Bildet sie den sichersten Ausgangspunkt für die Auffindung der Windungen.* . . . ."

§ 230. Form or course in detail.—According to Broca it normally presents two cephalic convexities with an intermediate caudal convexity. In most adults it is certainly more or less serpentine or tortuous and the regular curves are sometimes distinct; but three cephalic convexities have been observed in sufficient number to show the need of careful observation and tabulation.

§ 231. Branches.—Offshoots from the central are usually rather short and straight, starting at the summits of the curves; but in the brain presenting the most decided curvatures (Fig. 4778) there is scarcely any branching.

§ 232. Junctions.—So far as the writer is aware, connections between the central and other fissures (excepting the intercerebral, § 236) are rare, and incomplete or shallow when they occur; *e.g.*, in Fig. 4777, where the concealed vadum between the central branch and the supercentral nearly reaches the surface, and in Fig. 4778, where there is also a nearly invisible vadum just at the apparent union of the supercentral with the central. The occasional confluence of the central with the Sylvian over the margin of the operculum is commonly shallow, but sometimes quite deep, as in the right hemicerebrum of James Evans, figured by Mills, *Journal of Nervous and Mental Disease*, vol. xiii., September, 1886. The depth of such straits should always be stated.†

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* In a fetal brain figured by [illegible] Pl. xxx.) the fis- [illegible]

† [illegible]

§ 233. Points illustrated upon Fig. 4777.—The visibility, in an oblique view, of a feature invisible in either direct view, dorsal (Fig. 4772), or lateral (Fig. 4767, 21), viz., the existence of an isthmus separating the cephalic branch of the central fissure from the caudal branch of the supercentral, and thus maintaining the continuity of the precentral gyre.

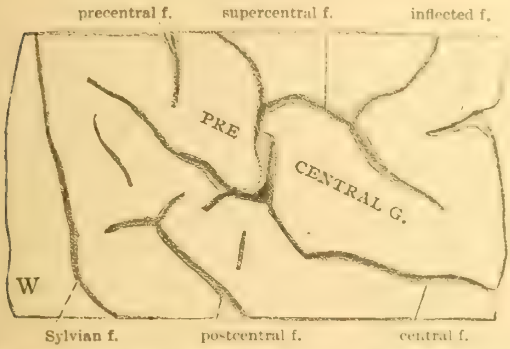

Fig. 4777.—Dorso-lateral Aspect of Part of the Left Hemicerebrum of the Mulatto Brain represented in Fig. 4767.

§ 234. Points illustrated upon Fig. 4778.—A. The unusual number of minor fissures, especially of the slight depressions which are called *fossulæ*.

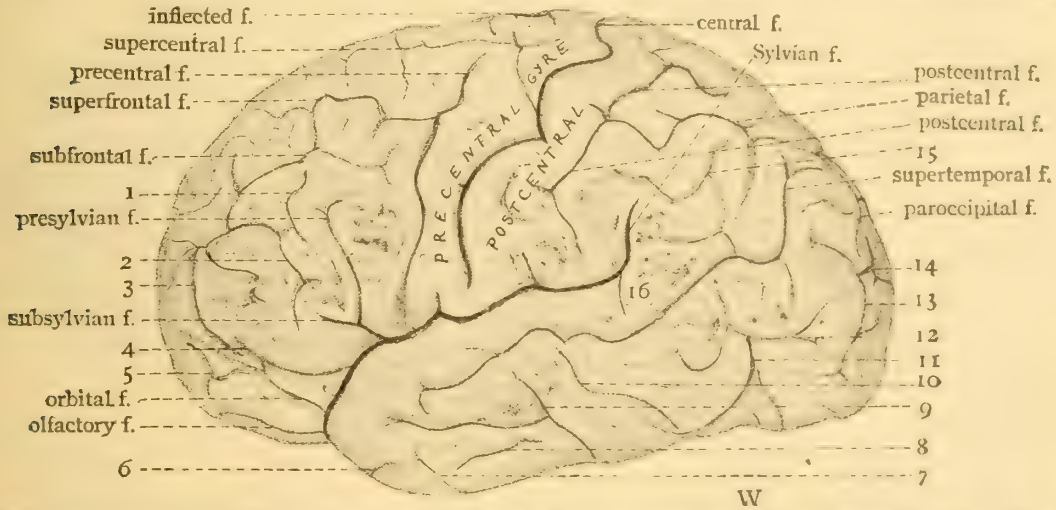

Fig. 4778.—Lateral Aspect of the Left Hemicerebrum of an Adult Hungarian Carpenter, Presenting an Unusual Degree of Fissuration. 385 6. *Preparation.*—The hemicerebrum was hardened resting upon the mesal surface, and apparently with little change in form. The right was likewise numerously fissured. Of the unidentified fissures the only ones that seem to call for comment here are 9 and 10, which are transtemporal fissures, and 16, a well-marked hyposylvian.

B. The three cephalic curves of the central fissure, and their decided character.

C. The extent of the supertemporal fissure.

D. The continuity of the postcentral, parietal and paroccipital fissures.

E. The union of the presylvian and subsylvian, and the concomitant separation of the preoperculum from the postoperculum.

F. The length of the presylvian.

G. The two dorsal branches of the Sylvian, and the distinct hyposylvian branch (16).

H. The crossing of the temporal lobe ventrad of the supertemporal fissure by two transtemporal fissures.

§ 235. Bifurcation.—Terminal division of the central fissure at either end is rare; there are but two instances of it among the brains examined by the writer.

§ 236. Relation to the mesal aspect.—Ecker and Quain imply that the central fissure usually ends at or near the dorsal margin; Gegenbaur and Schwalbe admit that it may cross the margin occasionally or even frequently. Among twenty-five adult hemicerebrums in the museum of Cornell University, January 5, 1889, with five the fissure distinctly fails to reach the margin; with four it just reaches it; with the other sixteen it extends upon the mesal surface for at least one centimetre. So far, therefore, as concerns these undisturbed preparations, the central fissure, although mainly lateral, is entitled to mesal representation in sixty-five per cent.

§ 237. Special location.—About midway between a line coinciding with the precentral and supercentral fissures cephalad, and a line coinciding with the postcentral and ventral part of the parietal caudad.

§ 238. Geometrical relations to the hemicerebrum as a whole.* A. A straight line representing the greatest length (fronto-occipital diameter) of the cerebrum usually crosses at or near the ventral end of the fissure. B. If the middle of this line be determined, the ventral end of the fissure will be found cephalad of the point at a distance equal to about one tenth of the entire line. C. If a perpendicular be drawn dorsad from the middle of this line, it will intersect the fissure at about the middle of its length. D. If the distance from the angle between the frontal and orbital outlines to the angle between the occipital and ventral outlines be measured along the mesal margin of the hemicerebrum, the dorsal end of the fissure will be found at a distance of about fifty-eight hundredths of the whole from the orbito-frontal angle. E. On the mesal aspect, if, from a line representing the greatest length of the hemicerebrum, there be drawn a perpendicular passing the caudal margin of the callosum, it will commonly meet the dorsal end of the central fissure at the margin of the hemicerebrum.

§ 239. The fissure-plane.—This term is employed to designate the entire length and depth of the fissure; the fissure-line is the ectal or superficial margin of the plane. If a hemicerebrum, hardened in the cranium, be transected obliquely along the course of the central fissure, and either half be so held that the mesal surface coincides in direction with the visual axis, the following points may be noted: A. The dorsal half of the exposed surface (including both the cut area and the intrafissural) constitutes very nearly the quadrant of a circle, rounded at the dorso-mesal angle where the fissure cuts the margin. B. The ectal (superficial) margin of the fissure plane coincides very nearly with the periphery of the quadrant. C. The ental margin, the line formed by the bottom of the fissure, is neither depressed at its middle, as with most fissures, nor even straight, but actually lower at the ends than at the intermediate region.

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* The surgically and pathologically important relations of the central fissure to the cranium and scalp are considered in the article Surgery of the Brain; also in *The Medical Record*, January 12, 1889.

§ 240. How to distinguish from adjoining fissures.—When the precentral is separate from the supercentral, and the postcentral from the parietal, the central is not only longer than either. When these two pairs of fissures unite, however, it is the middle of the group of three fissures at about the middle of the hemicerebrum having a general dorso-ventral direction. The following characters should be noted in case of doubt: its greater depth and length; its extension across the dorsal margin into the paracentral gyre; its location relatively to the entire length of the cerebrum and the angle it forms with the meson; its more complete independence, and the usual absence of terminal forks.

§ 241. Comments upon Fig. 4779.—Pending the detailed study and description of this very interesting brain by the writer, to whom it has been generously loaned from the Museum of Harvard Medical School, with the consent of its preparator and first describer, Dr. Thomas Dwight, the professor of anatomy, the following points may be noted: A. The great length of this hemicerebrum as compared with that of the mulatto (Fig. 4767).

B. The special length of the caudal part, whether the central or the Sylvian fissure be taken as the dividing line.

C. The height of the frontal region.

D. The apparently slight extent of the prefrontal lobe; apparently, because, as is shown upon the dorsal outline (Fig. 4781), a large part of this region is invisible from the side, and is of unusual width.

E. The simplicity of the visible gyres, due to the few connections of the main fissures, and the comparative infrequency of minor ones; partly, because the mesal cephalic surface of the prefrontal lobe presents a much greater complexity.

F. The condition of the minor fissures as sharp incisions rather than as slight depressions, like those in the Hungarian brain (Fig. 4776).

G. The visibility of the insula, at least equal to that in the mulatto (Fig. 4767). Whether any of this condition is due to the pressure during hardening, which may have occasioned also a peculiar roundness of the temporal lobe, it is impossible to determine, and Dr. Dwight does not recall the condition of the parts when the brain was removed.

H. The great length of the supertemporal fissure and its dorsal subdivision.

I. The bifurcation of the Sylvian fissure, constituting perhaps an episylvian and hyposylvian as in the mulatto.

K. The complete independence of the precentral and subfrontal fissures.

L. The union of the proximal parts of the presylvian and subsylvian fissures so as to separate the pre- and postoperculum.

M. The presence of an unusual, curved fissure (14) ventrad of the postcentral.

N. The crossing of the temporal region ventrad of the supertemporal fissure by several irregular fissures (transtemporal).

O. The complication of the zygal form of the orbital fissure by a branch extending cephalad from the middle of the zygon.

P. The complete interruption of the central fissure by an isthmus which is more clearly indicated in the dorsal outline (Fig. 4781).

Q. The rounded form, fullness, or "plumpness" of the gyres, remarked by Dr. Dwight.

§ 242. Anomalies of the central fissure.—There are two conditions of the central fissure that are so unusual as to be properly termed anomalies, viz., its complete interruption, and its duplication.

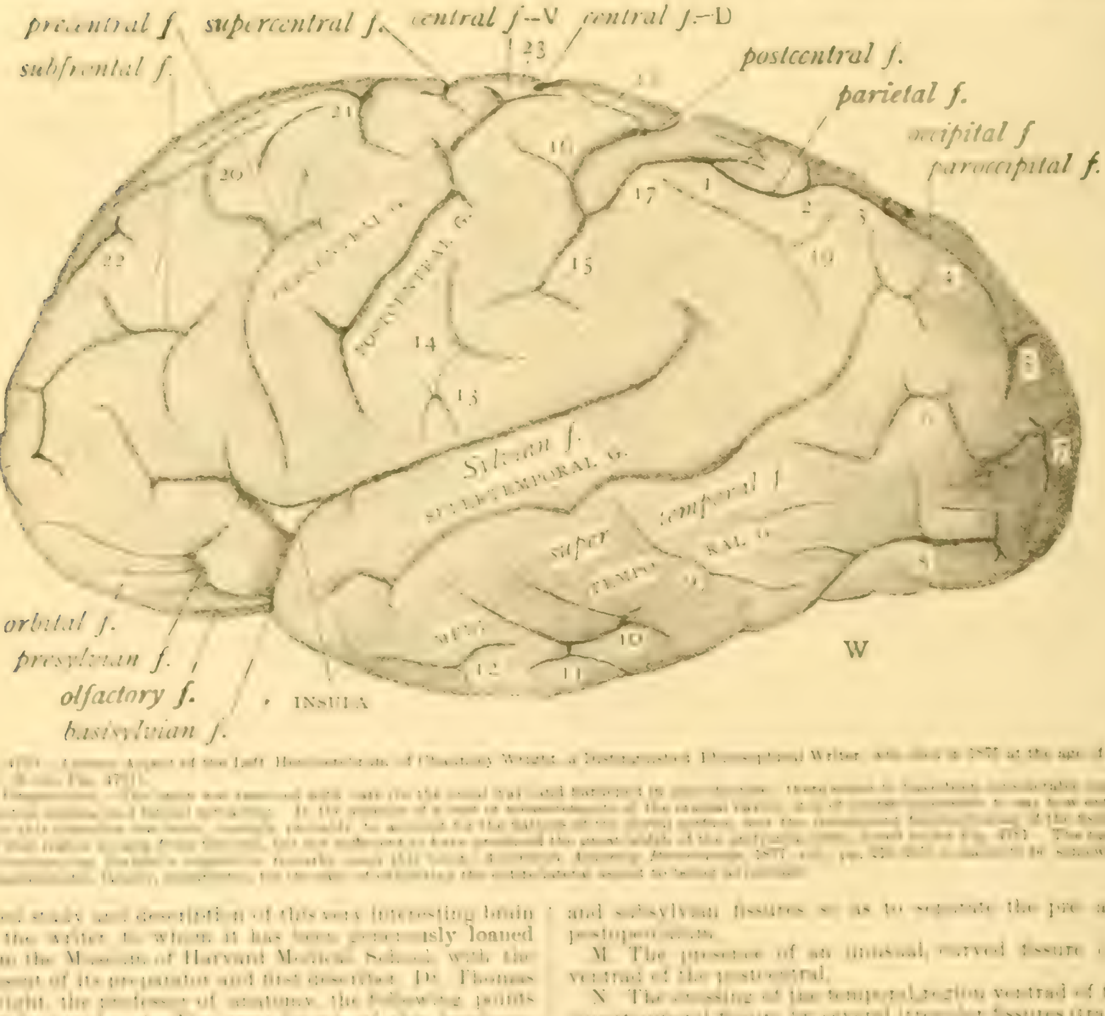

FIG. 4779.—Lateral Aspect of the Left Hemicerebrum of Chauncey Wright, a Distinguished Philosophical Writer, who died in 1875 at the age of 45. (C. Brain Fig. 4781.)

[illegible]

§ 243. Duplication.—Giacomini and Calori have each described a brain in which there are apparently two central fissures, nearly parallel and distinctly separated by an "intercentral gyre."

§ 244. Interruption.—As shown in Figs. 4779 and 4781, the central fissure is completely interrupted on both sides of the brain of Chauncey Wright, the isthmus * being fully on a level with the adjacent gyres. The brain of Dr. Fuchs, figured by Wagner, exhibited a like peculiarity, and the complete interruption has now been recorded for at least ten (perhaps twelve or fourteen) hemicerebrums, a very small proportion of the enormous number of brains examined.

§ 245. Points illustrated upon Fig. 4780.—A. The interrupted condition of both central fissures at their first formation.

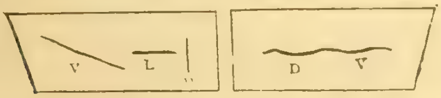

FIG. 4780.—Diagrams of the Right and Left Central Fissure Regions of a Fœtus, 56 ctm. Long and Estimated at 20 Weeks. 827 ; 2.

B. The lack of symmetry ; on the right are two parts, the right ventral (V) being 2 mm. deep at its middle and the dorsal (D) 2.5 mm.; on the left are three distinct divisions—the dorsal parallel with the meson, the lateral at right angles with it, and the ventral oblique.

§ 246. Partial interruption.—Dwight and Heschl have called attention to the not infrequent presence of a vadum or shallow in the depths of the central fissure, commonly nearer the dorsal end ; among 1,087 hemicerebrums examined, Heschl found in 152 (about fourteen per cent.) an elevation rising from one-sixth to five-sixths of the entire depth of the fissure, and suggests that the rare cases of complete interruption result from the greater development of this feature. In view of these observations the vadum should always be looked for.

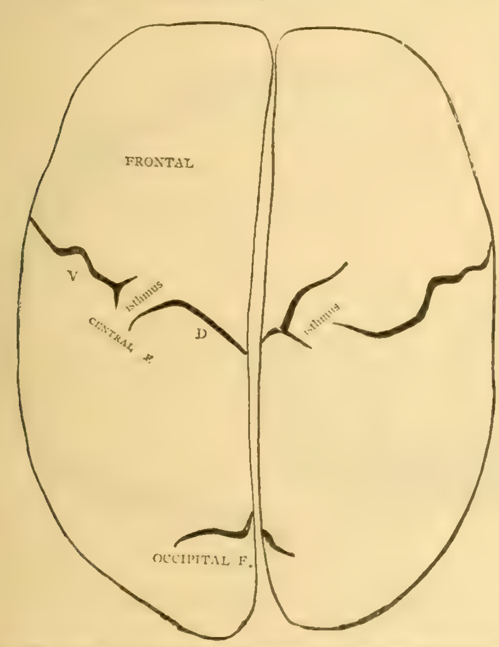

FIG. 4781.—Dorsal Outline of the Cerebrum of Chauncey Wright, Including only the Central and Occipital Fissures. × .5.

§ 247. Points illustrated upon Fig 4781.—A. The unusual width and squareness, of the prefrontal lobes, whence a direct lateral view of either hemicerebrum fails to include what is, on the whole, the most richly fissured surface ; see Fig 4779.

B. The complete interruption of the central fissure on each side by an isthmus which is level with the general surface and thus unites the precentral and postcentral gyres (see § 244).

§ 248. Time of first appearance.—Nearly all writers state that the central fissure is formed about the end of the fifth month, the twentieth week. The following observations show that there is probably some variation in this respect, or—as is perhaps equally probable—that the length of the fœtus varies considerably at the same stage of fissural development. In fœtuses 827 and 1817, respectively 56 and 65 ctm. long, the fissure is vague or absent ; in 1820, 61 ctm. long, it is distinct and deep ; in 2278, 67 ctm. long, it is well-developed, and several other lateral fissures are visible.

§ 249. Relative order of appearance.—Excluding the transitory fissures (Fig. 4756) and the lambdoidal (which may be transitory) the central is apparently the first of the lateral fissures to be developed after the Sylvian (Fig. 4759). But some of the writer's preparations indicate that this order may not be invariable ; in 2081 the parietal and supertemporal are more advanced than the central ; in 1817 there is no trace of a central, although both superfrontals are distinct. Numerous and careful observations are needed on this point.

§ 250. Form in the fœtus.—When first distinctly formed, the fissure line is nearly straight, with a slight cephalic convexity (Fig. 4759).

§ 251. Proximate cause.—According to W. Krause (as stated in *Quain*, ii., 332), in the fœtus, between the fourth and sixth months, the medicerebral vein is connected with the longitudinal sinus by a vein which atrophies later ; the writer has not been able to consult Krause's original statement, or to verify its accuracy.

§ 252. Relation to primitive fissures.—There is no good reason for regarding either of the three radiating, presumably transitory, fissures shown in Fig. 4756, as the direct precursor of the central.

§ 253. Integrality.—For the definition of *fissural integer* see § 217. The occasional, complete interruption (§ 244), the not infrequent existence of a vadum (§ 246), and the mode of appearance in one case (Fig. 4780), suggest the possibility that the central consists really of two fissural integers, commonly connected, and comparable, perhaps, with the parietal and paroccipital (§ 217). For the present, however, it seems justifiable and certainly more convenient to regard the conditions above named as anomalous, and to treat the central as a single fissure.

§ 254. Lateral variation.—Clevenger states that it is usually located farther caudad on the left side than on the right ; its relations to motor areas would lead one to expect considerable lateral variation in position, direction, and shape.

§ 255. Physiological and surgical relations.—It is completely surrounded by important motor areas, and its exact relations to the cranium and surface of the scalp are of great pathological and surgical importance ; these matters are considered in Vol. I. of this work, pp. 642-648, and in Surgery of the Brain, in this volume.

§ 256. Psychological relations.—Clevenger has a suggestive paper (*Journal of Nervous and Mental Disease*, April, 1880) on the ratio between the location of this fissure and the intelligence of the individual or species ; although unable to admit his identification with the cruciate fissure of Carnivora, or to accept all his conclusions, the writer regards the determination of the relative bulk of the precentral (frontal) region of the cerebrum and the postcentral (occipito-parieto-temporal) region as of great importance, in connection with the comparison between individuals and species in respect to intellectual power and voluntary inhibition or self control.

§ 257. Condition in other Primates.—In the apes and in all the ordinary monkeys the fissure is readily recognized ; *e.g.*, in the *Macacus*, Fig. 4788.

§ 258. Carnivoral representative.—By various authors (see "Anat. Technology," § 1370) it has been homologized with the following features of the ... superorbital, ... and ... Notwithstanding the ... relations of the ... and ... fissures to ... areas, the question of their homology (morphological identity) must be held as yet undetermined; see

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* This term is equivalent to *pli de passage*, *annectent convolution* and *bridging convolution* ; the latter is misleading, for the interruption of a fissure has no analogy with a bridge, but rather with a dam, dyke, or isthmus, absolute size being of no moment.

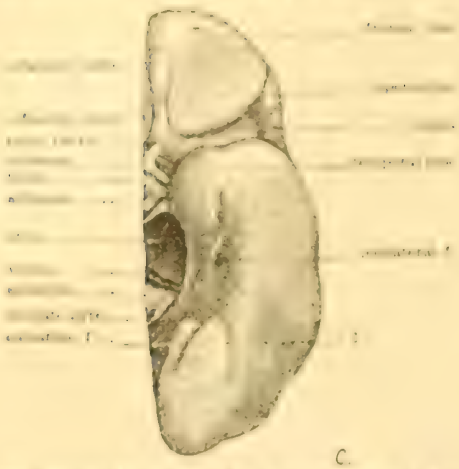

FIG. 4782.—Ventral Aspect of the Left Hemicerebrum of a Fœtus [illegible]. The lateral aspect of the same preparation is shown in Fig. 4759. See § 264.

also the writer's remarks in *Journal of Nervous and Mental Disease*, July, 1885.

§ 259. Prop. CXXXVII. *Collocation of fissures with cranial sutures.*—In the adult the dorsal end of the occipital fissure has a notably constant position at the mesal angle of the lambdoidal suture, as seen in Fig. 4684. With fœtuses of between three and seven months this suture is decidedly caudad of the occipital fissure, but is distinctly collocated with the lambdoidal fissure (Fig. 4758); this collocation does not persist after the seventh month, and it is not yet known whether the fissure disappears or changes its position. The approximate collocations of the central and other fissures with sutures are considered in the article Surgery of the Brain.

§ 260. Prop. CXXXVIII. *Supergyres and subgyres.*—The ectal surfaces of two adjoining gyres are commonly at about the same level, excepting for a marked change in the general contour of the cerebrum, as, *e.g.*, at its several ... But sometimes one gyre may be developed much more than its neighbor, and encroach upon it so as to conceal it more or less completely. The covering gyre may be called a supergyre, and the covered a subgyre.

§ 261. Prop. CXXXIX. *Superfissures and subfissures.*—These terms are employed herein to designate the fissures which result from the formation of supergyres and subgyres. The line of overlapping of a supergyre is a superfissure, as also is the line of junction of two supergyres meeting from opposite directions. A subfissure is one which is concealed by a supergyre, and invisible until the lips of the superfissure are divaricated.

§ 262. Prop. CXL. *Normal fissures and subfissures* are the circuminsular, which encircles the insula (Fig. 4783), the transinsular and others crossing the surface of the insula (Figs. 4715 and 4783), and those which indent the ectal or insular surfaces of the opercula (Fig. 4784). Unusual subfissures appear in Fig. 4787, after the removal of the unusual supergyre; superfissures are shown also in Fig. 4788.

§ 263. Prop. CXLI. The insula ("Island of Reil") and the operculum constitute normal and typical examples of subgyres and supergyres. As may be seen in Figs. 4715, 4752, 4759, 4760, 4782, and 4784, and in the diagram, Fig. 4765 (B), the insula is a part of the cortex which, at one period wholly superficial, is gradually covered, more or less completely, by converging folds of the adjacent regions. The insula thus becomes a subgyre, while the operculum, preoperculum, suboperculum, and postoperculum are supergyres. For other supergyres see §§ 271 and 276.

§ 264. Points illustrated by Fig. 4782.—A. The continuity of the insula with the lateral root of the olfactory crus.

B. The partial covering of the insula at this period.

C. The thickness and roundness of the margin of the operculum.

D. The formation, at this period, of the presylvian fissure constituting the cephalic limit of the operculum, but the non-existence of a subsylvian fissure.

E. The length of the olfactory bulb at this period, as compared with its crus, which latter is the longer in the adult.

F. The concealment of the entire olfactory fissure by the olfactory bulb. In the adult, usually, the fissure projects considerably beyond the bulb (Fig. 4689).

§ 265. Prop. CXLII. The insula has notable topographical relations with (*a*) the several opercula, (*b*) the claustrum and lenticula. Although perhaps, upon the whole, most developed in man, relatively to the size of the entire brain, it is perfectly distinct in apes and monkeys, in dogs, the porpoise, and (according to Spitzka) in several other mammals. Its comparative anatomy and its human variations are fruitful and important subjects for further observation: see the papers by Spitzka (N. Y. *Med. Record*, January 6, 1879), Eberstaller (*Anat. Anzeiger*, May 15, 1888, p. 582, and references there given), and the writer (*Jour. of Nerv. and Mental Disease*, xii., July, 1885).

§ 266. Points illustrated on Fig. 4783.—A. The location and common form of the insula.

B. The existence of fissures and intervening gyres radiating in general from its summit.

C. The division of the whole by a somewhat deep fissure, the transinsular (2), into a cephalic region, *prœinsula*, and a caudal, *postinsula*. Other views of the insula, young and adult, are given in Figs. 4759, 4760, 4762, 4767, 4779, 4782, and 4785.

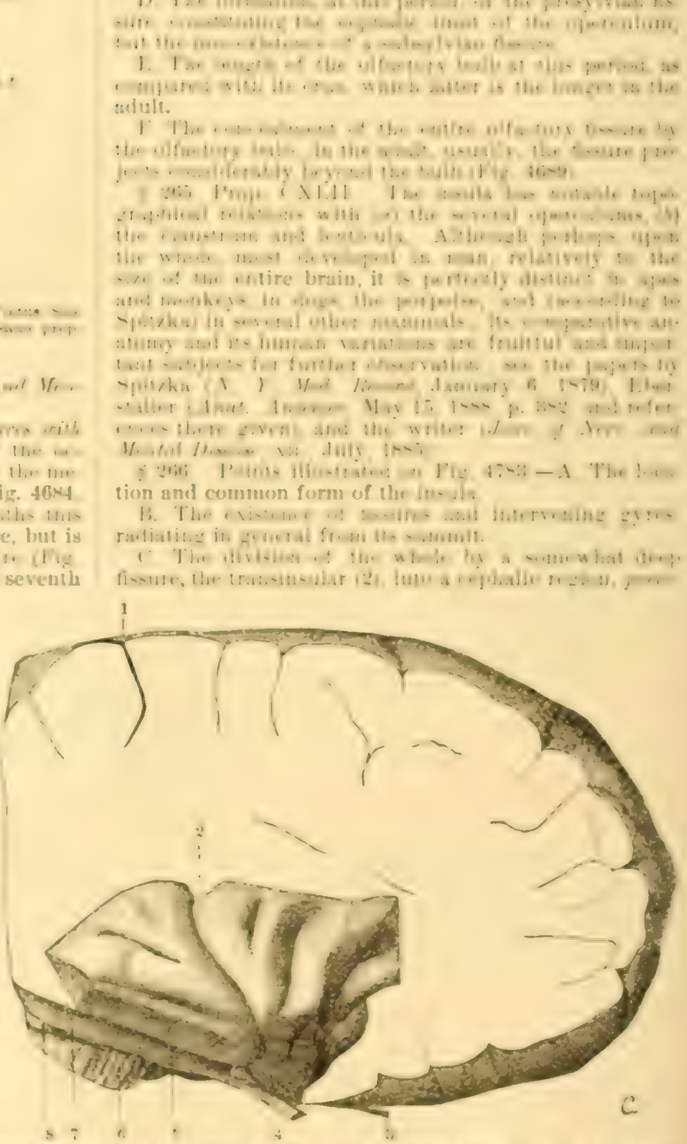

FIG. 4783.—Right Adult Insula Exposed from the Lateral Aspect. (B. G.) 1, Central fissure; 2, transinsular fissure; 3, olfactory crus; 4, optic nerve; 5, [illegible]; 6, [illegible]; 7, preoperculum; 8, postoperculum.

§ 267. Prop. CXLIII. The *operculum* is not strictly a single gyre, but includes portions of at least two, the precentral and the subfrontal. It is as if the eastern half of the southern extremity of Africa were owned by the Dutch and the western by the English, each half having its own territorial designation; we might still speak of

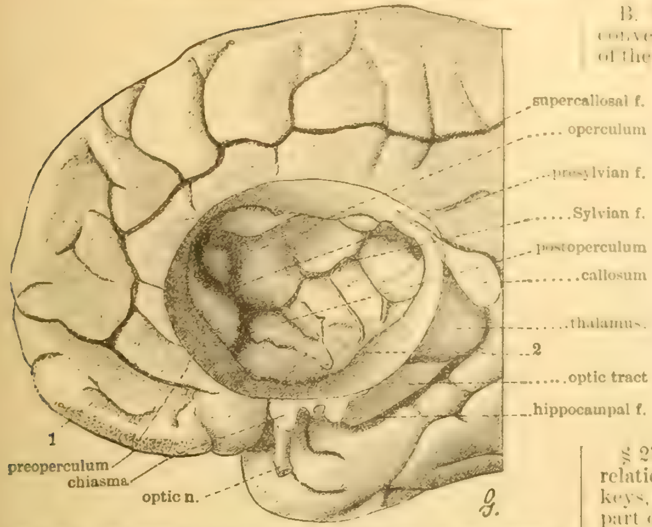

FIG. 4784.—The Mesal Aspect of the Right Operculums of a Child at Term. 1823 : < 1.

Preparation.—The hemicerebrum had been hardened in alcohol while resting on the meson, and hence is a little thinner and wider than natural, but thereby better suited to the desired object. A probe was pushed through from the lateral aspect at the triangular place of divergence of the Sylvian, basisylvian, and presylvian fissures; from the hole so made upon the mesal aspect, cuts were carried in various directions, cautiously, until most of the thalamus, caudatum, lenticula, and insula were removed, thus exposing the ental or mesal surfaces of the operculum, postoperculum and preoperculum, with the intervening Sylvian and presylvian fissures.

Defects.—The inclusion of the occipital region would have rendered the figure somewhat more intelligible. The suboperculum and subsylvian fissure are not exposed ; the cut surface at the ventral side should be traversed by a line starting from just cephalad of the chiasma to represent that part of the basisylvian fissure.

the Cape of Good Hope, composed by the two countries. In general the same may be said of the postoperculum, sub- and preoperculum.

§ 268. Points illustrated by Fig. 4784.—A. The extent to which the several operculums lap over the insula, constituting so many supergyres.

B. The fissuration of the ental surface of the operculums.

C. The distinctness of the supercallosal fissure, and the absence of a fronto-marginal between it and the dorsal margin of the hemicerebrum.

D. The presence of the amygdaline fissure, partly concealed by the optic nerve.

§ 269. Points illustrated by Fig. 4785.—A. The existence of two zones of the lenticula, an ectal, the putamen, and a second, ental of the first, as seen from Fig. 4732 ; there is still a third, but it does not extend sufficiently far dorsad to appear in this or Fig. 4731.

B. The constitution of the insula as an elevation of the lateral region of the hemicerebrum, its cortex and medulla being continuous with the rest and with the overlapping operculums.

C. The peculiar form and location of the claustrum, a thin, subcircular disk of cinerea, between the putamen and the insular cortex, of which it is probably a dismemberment.

§ 270. Prop. CXLIV. Supergyres and subgyres occur by exception in other parts of the cerebrum, especially the occipital (see Figs. 4776 and 4777), and normally in many monkeys, the *poma*, § 272, Fig. 4788.

§ 271. Points illustrated upon Figs. 4786 and 4787.—A. The presence of a postcuneal fissure along the caudal margin of the cuneus ; its dorsal end is free, but ventrad it has a very shallow connection with the calcarine.

B. The concealment, in the undissected brain, of the convexities of the paroccipital fissure and gyre and part of the occipital fissure by an extensive supergyre, analogous to, though probably not homologous with, the poma (occipital operculum) of monkey brains (Fig. 4788).

C. The conversion of the paroccipital fissure and gyre into a subfissure and subgyre.

D. The apparent continuity of the exoccipital with the occipital in the undissected brain.

E. In general, the desirability of checking all conclusions based upon the obvious features of the cerebrum, by an examination of the concealed conditions.

§ 272. Prop. CXLV. The so-called "external occipital," or "external perpendicular," fissure of monkeys is a superfissure, factitious, variable, and heterogeneous, resulting from the lapping of a supergyre, the *poma* ("occipital operculum"), upon the parts cephalad of it ; it may therefore be called the *pomatic* fissure.

§ 273. Points illustrated upon Fig. 4788.—A. The relation of the poma ("occipital operculum") of monkeys, as a typical supergyre, to the paroccipital and part of the supertemporal, which are here subgyres.

B. The relation of the pomatic ("external occipital") fissure of monkeys, a typical superfissure, to the paroccipital and occipital fissures, which are here wholly or partly subfissures.

C. The, so to speak, factitious nature of the pomatic fissure, since it results, not from the opposition of two adjoining and approximately equal gyres, but from the lapping of one over the crests of those adjoining ; as may be seen by comparing the two sides, it really comprises three distinct parts, viz., a lateral, between the

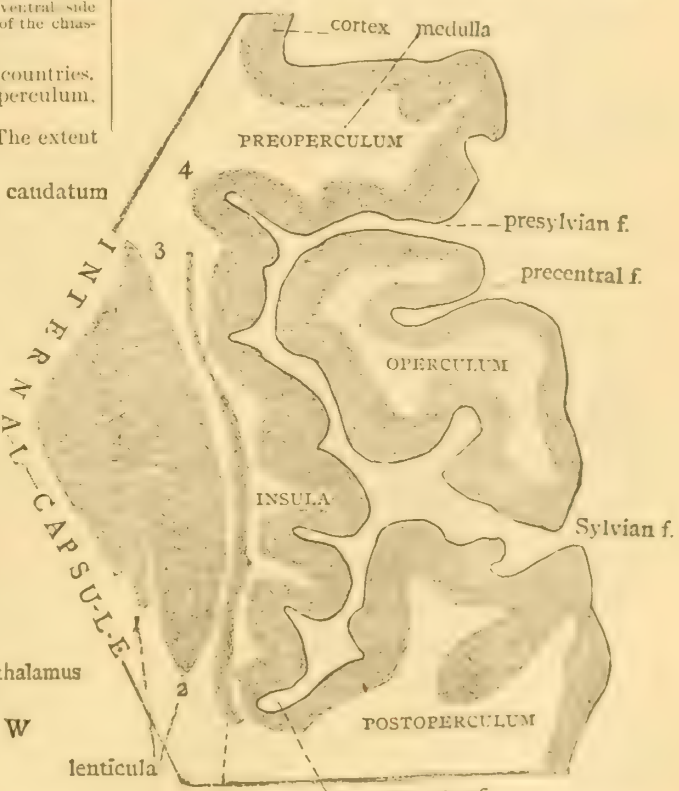

FIG. 4785.—Longisection of the Right Insula and Adjacent Parts. [illegible] Enlargement of the corresponding region of Fig. [illegible]. 1, 2, [illegible] the latter and larger the putamen ; 3, the stratum of alba between [illegible] claustrum, sometimes (most undesirably) called "external capsule" ; 4, [illegible] of circuminsular fissure. *Internal capsule* should be [illegible].

pomatic margin and the ental surface of the temporal gyre; an intermediate, connecting with the cephalic slope of the paroccipital fissure; a space, formed by the

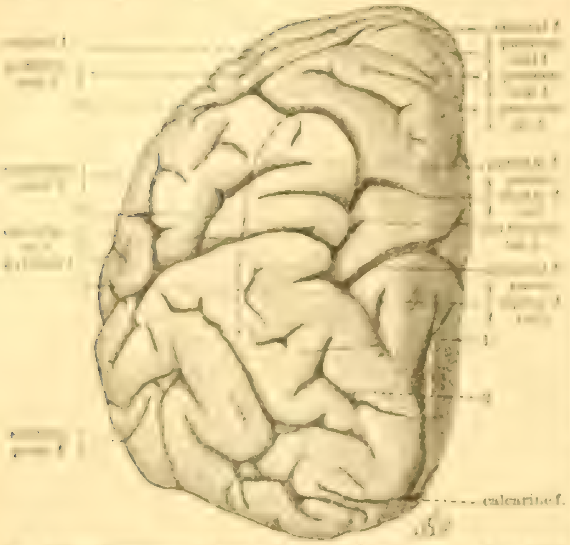

Fig. 4786.—Dorsocaudal Aspect of the Left Hemicerebrum of an Adult [illegible]

For the preparation, see Fig. 4786.

pomatic margin and the paroccipital gyre. Finally, since the dorsal termination of the occipital fissure is covered by the poma, there results an apparent continuity of the pomatic and occipital fissures.

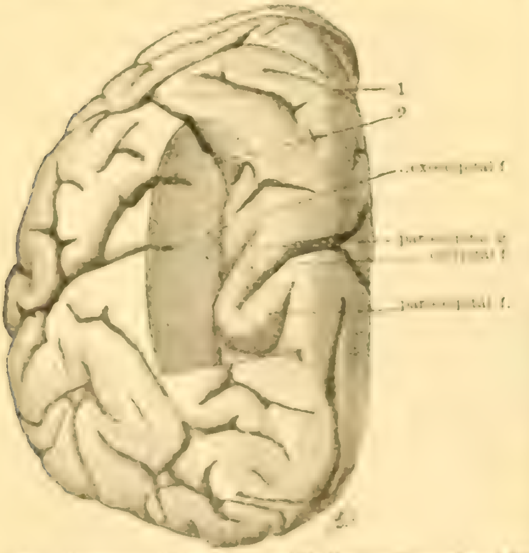

Fig. 4787.—Dorsocaudal Aspect of the Left Hemicerebrum of an Adult [illegible]

[illegible]

D. The continuity (depth not determined) of the paroccipital fissure with the occipital.

E. The junction of the Sylvian and supertemporal fissures.

F. The distinctness of the "angular gyres."

G. The existence of peculiarities and complexities which in the judgment of the writer render monkey brains less serviceable than those of human fœtuses for the elucidation of several problems.

§ 274. Prop. CXLVI. Under the various titles "external perpendicular," "external occipital," "temporo-occipital," "ape fissure," "exoccipital," etc., have been included several different human fissures or combinations of fissures, viz.: (A) The dorsal extreme of an unusually deep occipital fissure, Marshall, "The Brain of a Bushwoman," *Philosophical Transactions*, cliv., p. 5[illegible], Figs. 1, 2, 3; (B) a fissure on the lateral aspect, caudad of the supertemporal, and having a general dorsoventral direction: the vordere occipital of Wernicke ("Das Urwindungssystem des menschlichen Gehirns," *Arch. für Psychiatrie*, 1876, Pl. v., Figs. 19 and 22), called *exoccipital* in the present article in order to

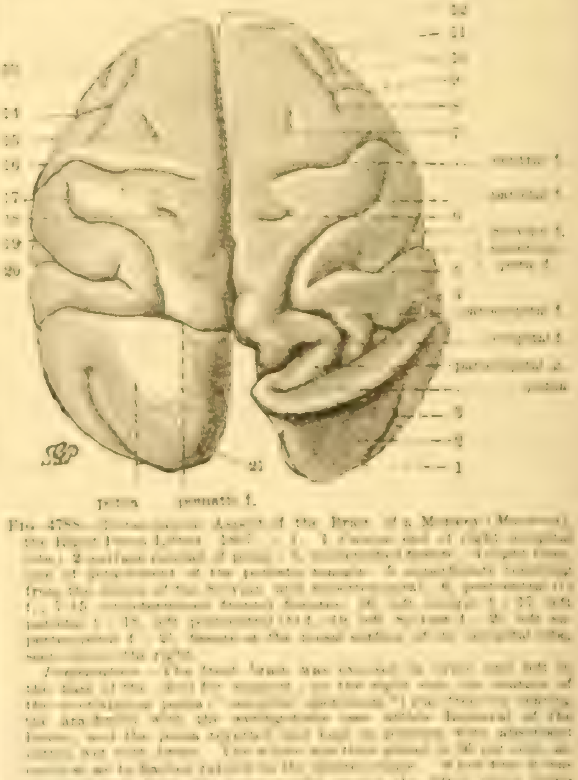

Fig. 4788.—Dorsocaudal Aspect of the Brain of a Monkey (Macacus), [illegible]

Preparation.—[illegible]

avoid using the more natural synonym, *preoccipital*, already applied elsewhere by Meynert; (C), the combination of A and B,* on account of a supergyre which covers the dorsal end of the true occipital fissure (A) and permits the adjacent end of B to apparently become continuous with it, as in Figs. 4786 and 4787.

§ 275. Prop. CXLVII. No one of the fissures or fissural combinations mentioned in § 274 is identical with the pomatic fissure of most monkeys; but the exoccipital may exist in the true apes and in *Ateles* (Huxley, *Zool. Proc.*, 1864, Pl. xxix.). It is doubtful whether the term "ape fissure" is a desirable one to retain.†

§ 276. Prop. CXLVIII. The depth of fissures should be determined either (*a*) by sounding, as practised by Jensen (*Archiv für Psychiatrie*, 1874, p. 596) or by the careful removal of interfissural blocks capable of being replaced and secured by pins, as represented, *e.g.*, in Figs. 4776 and 4787.

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* [illegible]

† [illegible]

§ 277. Prop. CXLIX. The fissures of idiots, of insane persons, and of criminals are usually peculiar; whether these peculiarities have the significance sometimes ascribed to them, and especially whether murderers' brains present characteristic features, are questions of exceeding interest and importance. The writer does not feel ready, as yet, to discuss them, but refers with confidence to the admirable paper of Dr. Charles K. Mills, *Jour. of Nerv. and Mental Disease*, 1886, September and October.*

§ 278. Prop. CL. It seems at least probable that the well-marked human races present fissural peculiarities; careful figures and descriptions of such are not yet numerous enough to serve as a basis for useful generalization. The paper of Dr. Mills above cited refers to mulatto brains, and contains figures and a preliminary description of a Chinese brain, a most rare and interesting specimen. The brain of a Bushwoman has been described and figured by Marshall (see § 274), and that of a Hottentot is discussed by Wyman, *Boston Soc. Nat. Hist. Proceedings*, ix., 353.

§ 279. Prop. CLI. Abundant fissuration is of course one of the factors in cortical extension, but not the only or perhaps the principal one. Whatever may be the average derived from a considerable number of cerebrums, more or less fissured, there occur exceptions, such as the two brains shown in Figs. 4778 and 4779. The mechanic's cerebrum is fissured to an unusual degree and the insula completely hidden; the philosopher had a larger brain, but its lateral aspect presents an equally unusual absence of fissural complexity and the insula is exposed.

§ 280. Prop. CLII. For the determination of the correlation between mental characteristics and cerebral peculiarities it is desirable that the brains of well-known persons of marked idiosyncrasies should be carefully preserved and thoroughly studied. Among the individuals best adapted to subserve this object are college professors, who have usually somewhat sharply defined capacities and attainments, and are the subjects of prolonged and discriminating observation and discussion among their trustees, colleagues, and students; no professor's brain should be lost to neurological science.

§ 281. Prop. CLIII. Considerable interest attaches naturally to the comparisons of brains as to *weight*, absolute and relative, and as to other points, between individuals, the sexes, races, ages, and different species. Any present statement of the case must be largely negative and qualified, hence neither compact nor altogether satisfactory. Many of the following figures and generalizations are taken from the excellent account of the subject in *Quain*, ii., 382–384.

§ 282. Prop. CLIV. In comparing brains, and especially cerebrums, the following data are desirable but seldom all attainable. 1. Absolute weight, after removal of the dura. 2. Relative weight, *i.e.*, in comparison with that of the entire body. 3. Weight of the cerebrum, including the thalami. 4. Form (very difficult to determine upon the fresh brain). 5. Degree of fissuration. 6. Depth of fissures. 7. Arrangement of fissures. 8. Age. 9. Sex. 10. Cause of death. 11. Degree of emaciation. 12. Mental state (insanity, etc.). 13. Thickness of cerebrocortex. 14. Firmness of the cortex. 15. Chemical and histological integrity.

§ 283. Prop. CLV. The *average weight* of the adult human brain, according to Quain (ii., 382), is 1,247 grams (44 oz. avoir.) for the female and 1,400 (49.4) for the male. The more recent conclusions of Bischoff and Mendel make both these a trifle lower. In a series of 278 male brains, the *maximum weight* was 1,842 grams (65 oz.) and the *minimum* 964 (34 oz.). Among 191 female brains the corresponding figures were 1,587 (56) and 879 (31). Certain female brains are heavier than certain male; for example, Gambetta's weighed only 1,180 (41.62), while that of an insane woman fifty-seven years old (No. 2268 of the Cornell University Museum), has an *alcoholic* weight of 1,285, and (assuming this to represent 80 per cent. of the original) may have weighed 1,606 when fresh. It is to be noted, however, in this connection (1) that there are some reasons for regarding unusual weight as a not infrequent concomitant of mental disturbance; and (2) that there are not, as yet, recorded the brain-weights of any women known to have been intellectually superior. The comparison between the two sexes is not, therefore, altogether satisfactory.

§ 284. Prop. CLVI. In *absolute weight* the human brain is exceeded by those of whales and porpoises (2,265–3,171 grams, 5–7 pounds) and of elephants (4,530 and upward, 10 pounds or more). The lowest of these figures is higher than the greatest weight (1,983.80, 70 oz., or 4 pounds 6 oz.) claimed for a *non-hydrocephalic* human brain, viz., that of a negro described by Dr. C. Tompkins, *Virginia Med. Monthly*, Jan., 1882, pp. 291–293.*

§ 285. Prop. CLVII. But in no animal other than those mentioned above (§ 284) is the brain as heavy as the smallest human, viz., that of a Bushwoman, 871 grams (30.75 oz.).† In a bull it was 337 grams, in a lion, 198, and in an adult gorilla only 425 (15 oz.) (Owen, iii., 144). The largest ape brain is then only half as large as the smallest normal human.

§ 286. Prop. CLVIII. The *relative weights* of the body and brain vary greatly according to the condition of the former at death. Most of the cases tabulated were of persons dying after more or less prolonged disease, and the figures are as follows: for 81 males, 1 to 36.50; for 82 females, 1 to 36.46; according to Bischoff, 1 to 35.20. Quain concludes that in healthy individuals dying suddenly from disease or accident, the ratio is probably about as 1 to 45. In comparing man with animals in this respect this last ratio should commonly be adopted.

§ 287. Prop. CLIX. Owen estimates the adult male Gorilla at 200 lbs., or 90,720 grams, and the brain would be as 1 to 213; in a bull it was as 1 to 2,000, and in a lion as 1 to 555. On the other hand, in a sparrow the ratio was as 1 to 25; and in a marmoset (*Midas*) 1 to 20, (Owen, iii., 142); and in *Jacchus vulgaris* (No. 664, Cornell University Museum), as 1 to 19. But it is to be noted that in these small monkeys, as in birds, the cerebrum is *not fissured*. Perhaps the least misleading mode of stating the case is to say that the human brain is relatively heavier than that of any animal larger than a cat, in which the cerebrum is fissured.

§ 288. Prop. CLX. With many intellectually eminent men the brain-weight has been decidedly above the average (1,400 grams, 49.4 oz.); *e.g.:* Broca, 1,484 (52.34); Louis Agassiz, 1,495 (52.73); Schiller, 1,580 (62.96); Cuvier, 1,861 (65.64, commonly given as 64.50); Turgenieff, 2,120 (74.74). Yet the weight has been below the average with several persons of undoubted mental power, *e.g.*, Gambetta, 1,180 (41.62); Dante, 1,320 (46.56); Liebig, 1,352 (47.69). Finally, with several unintellectual individuals the brain-weight has been high, *e.g.*, a bricklayer who could neither read nor write, 1,899.45 (67 oz.), re-quoted by Dr. Morrison (*British Medical Journal*, October 26, 1878). Of people mentioned in § 284, [illegible] (70 oz.) Morselli [illegible] p. [illegible] that the brain weighing less than 900 grams (32 oz.) were more or less idiotic, but this perhaps applies to the white males only. Taking all exceptions into account, it is probable that the average of any 100 brains of intelligent persons would always be found heavier than that of an equal number of the illiterate; but since correct form is an element of intensive as well as of extensive value, it is very desirable that, as well observed by Topinard, there should be careful examination of the differences of the weight of the brain among [illegible] belonging to the two distinct classes of (1) those who are engaged in intellectual pursuits, and (2) those whose vocations demand great muscular activity.

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* To some persons the idea that there is a "criminal type" of brain is very attractive; that this is not yet accepted by all neurologists may be seen from the following conclusions of Schwekendiek ("Untersuchungen an zehn Gehirnen von Verbrechern," etc., 1882), substantially as stated in the *American Journal of Neurology and Psychiatry*, i., 569–573: "These brains are irregularly developed, but we cannot yet assert that they present a reversion to animal brains or that there is a criminal type; with regard to Benedikt's chief claim that fissural confluence is characteristic of the criminal brain, just the reverse was found to be the case."

* The brain of a Chippewa Indian squaw, 85 years old, [illegible] Army Medical Museum, Anatomical Section, No. 1031, [illegible] fresh 73.5 ounces (2,083.72 grams) but it was *hydrocephalic* [illegible] rator, Surgeon J. S. Billings, U. S. A., [illegible] tricular liquid was probably included in the weight.

† It should be noted, however, that the weight of the [illegible] brain as here given was *estimated* by Marshall (*Philosophical Transactions*, cliv., 506) in the following way: The weight [illegible] alcohol was 21.77 oz. (617 grams). He assumed [illegible] twenty-fourths (between a third and a fourth) of the [illegible] weight, which would then have been as stated above. [illegible] tions lead him to regard the average loss of weight as only [illegible] *fifth*; upon this basis the original weight of the [illegible] only 771 grams (27.19 oz.), not quite double that of the Gorilla. [illegible] and repeated observations are needed to determine the [illegible] of weight of an adult human brain thoroughly hardened in alcohol.

§ 289. Prop. CLXI. According to J. Reid, as quoted by Quain (II., 284), the weight of the cerebrum (including the thalami and [illegible]) is to that of the cerebellum (with the pons and oblongata) as rather more than 8 to 1, which Owen states (III., 145) to be a higher ratio than in any other mammal.

§ 290. Prop. CLXII. Whatever value be ascribed to brain-weight, accuracy in its determination and statement should be rigidly observed. Especially essential is it that the scales and weights be verified, and that the weighing be done in the presence of two or more, each of whom should make an independent observation and memorandum. There are considerable discrepancies in the various accounts of the brain-weights of noted persons, *e.g.*, of Gambetta, 1,160 and 1,180 grams; of Turgenieff, 2,012 and 2,120; of Cuvier, 1,800 and 1,861. Sometimes there may be typographical errors, but more often the differences are due to the processes of reduction and re-reduction between the metric and other systems, or to the dismissal of fractions of the ounce; for example, the brain-weight of Cuvier is given commonly as 64 oz., sometimes as 64.5, neither perhaps exactly indicating the number of grams. Again, the retention of the falx or any other part of the dura will add considerably to the weight, while the removal of the pia, commonly retained, will diminish it. Finally, the brain tissue absorbs water quite rapidly if placed in it, and dries if left uncovered. All these conditions must be borne in mind and mentioned when the weight is stated, permitting each to make his own allowance therefor. Some other points in this connection are given in the article Removal of the Brain.*

§ 291. Prop. CLXIII. *Cortical extent.*—So far as may be judged, the surest criterion of potential cerebral power is the extent of the cortical surface. From the nature of the case this is very difficult to determine, and has, in fact, been determined for only four individuals. The Wagners, father and son, measured the cortical superficies, both exposed (intersulcal) and concealed (intrasulcal), with an ordinary woman, a workman, a mathematician, Gauss, and a clinical teacher, Fuchs. The results were, in the order named, 1,907.40 sq. ctm. ([illegible] sq. in.); 1,882.20 (291); 2,086.20 (323); 2,120.40 (328). Between the workman and the mathematician the difference was [illegible] sq. ctm., or [illegible] sq. in., very nearly the size of one printed page, which is about 250 sq. ctm. This difference is regarded by Quain as less significant than it appears to the writer.

§ 292. The history of encephalic anatomy is given by Vicq d'Azyr (1786) and Burdach (1822). Since the latter date the number of new parts discovered is small, the advances being rather in accuracy of description and delineation, and in the interpretation of the relations of parts to one another, and to the general mammalian and vertebrate types; see the treatises of Schwalbe and Henle, and the writings of Meynert, Spitzka, and others. From the nature of the case, greater progress has been made and is making in respect to the elucidation of histological relations, for which see the next article.

§ 293. The following list includes the principal treatises upon the gross anatomy of the brain, mostly recent, and likewise a few special papers. Other papers are named in the text. For the current literature of Neurology consult the following journals: [illegible] *Anzeiger*; *Zoologischer Anzeiger*; *Index Medicus*; *Neurologisches Centralblatt*; *Brain*; *L'Encéphale*; *Jahresbericht für Anatomie*, etc.

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Burt G. Wilder.

BRAIN: HISTOLOGY.

BRAIN: HISTOLOGY.—Physiologically considered the brain is composed of two forms of nerve tissue; the ganglionic and the conducting. The former is the active agent in the reception and registration of impressions, and in the evolution of motor impulses. The latter plays the more passive rôle of a conduit of these impressions and impulses. The essential and characteristic feature of the brain mechanism is the union of these two, and their consequent more or less direct connection with the various organs of the body. The chief task of modern brain histology has become the tracing out of the conducting tracts from the periphery through the white substance to certain ganglia. For example, a tract which is found to unite the retina to the external geniculate body is thus demonstrated to be a visual tract, while the external geniculate body is shown to be a visual centre. The thinking neuro-anatomist sees with his mental eye the opaque interior of the brain transparently resolved into an intricate yet well-defined set of projecting and associating mechanisms, connecting the functional mosaic of the cortical surface with the outer world, and binding it into that complex unity of functions which constitutes the mind. The analysis of brain-structure consequently exhibits a dovetailing of features visible to the naked eye, with those features that are visible only under high magnifying powers. The methods employed reflect this fact: they combine the macroscopic with the microscopic.

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* In addition to the books and papers cited in § 288, the following may be consulted regarding brain-weights: [illegible] "Brain-weights of Man and Woman," [illegible] 1887 [illegible] Popular Science Monthly [illegible] Topinard's summary of Broca's conclusions [illegible] 1882 [illegible] "Brain-weight and size in relation to [illegible]" [illegible] January 18, 1888, [illegible].

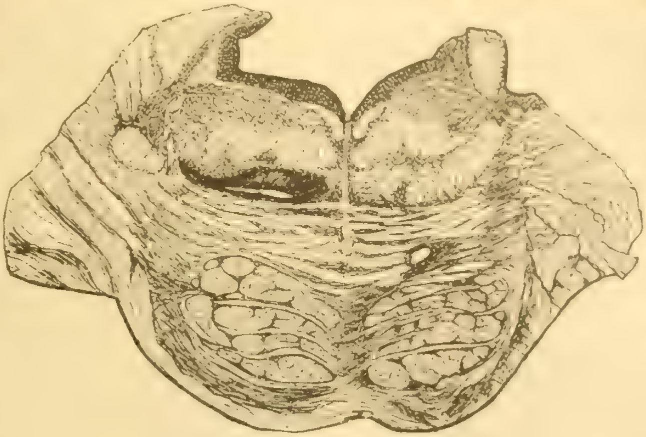
FIG. 4789.

Examination of the Fresh Brain.—The encephalon in the recent state is a more firm and resilient organ than is usually supposed, and, properly supported in a vessel imitating the shape of the cranial cavity, may be divided into a series of segments, transversely, sagittally vertical, or horizontal, which on close scrutiny exhibit delicate color shades, fine striations, and subtile transitions from white to gray matter, which become obliterated as decomposition advances, and much altered by the methods of preservation and hardening to be detailed. From the ganglionic depôts exposed by such sections small portions may be removed for teasing, for section in the freezing microtome, or for hardening.

Defibrillation of the Hardened Brain.—To the naked eye the fresh brain presents a large variety of details, but these relate rather to the topographical features of that organ than to physiological connections. The white substance, now known to embody numerous separate channels, each of which is endowed with a special functional rôle, appears a homogeneous mass without any specialization except in the crude form of commissures, of emerging nerve-roots, or of morphologically isolated strands such as the fornix. But on tearing asunder a brain hardened in alcohol, indications of specialized nerve-tracts are observed; strands are seen traversing the white interior of the convolutions, some passing like the rays of a fan from the basilar ganglia to the cortex (*corona radiata*), others skirting the latter like festoons (*fibræ propriæ*), and others connected with the commissures. Many facts elicited through this crude method by Goll, Rolando, Reil, and Burdach have been confirmed by more reliable methods. But defibrillation is as apt to lead to the registration of fortuitous as of true connections, and as a method of original research has been abandoned. Attempts made by Meynert and the younger Stilling—the latter beautifully modifying the older method by subsequent maceration of the hardened brain in acetic acid—have found no followers. As a means of demonstrating nerve-tracts established by other methods it is of value. Thus, by cutting a preliminary trench which is to guide the fracture, along the sulcus of Rolando, then boldly across the middle of the temporal lobe, along the outer third of the pes, the outer quarter of the pons, through the sulcus separating the olive from the pyramid, ending by a diagonal sweep in a plane running centro-laterad and dorsad, and making the fracture along the line thus indicated, the tract conducting voluntary motor impulses from the paracentral and Rolandic regions to the extremities may be demonstrated, even to its decussation.

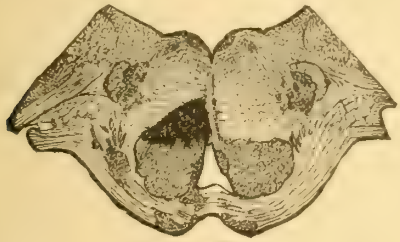
FIG. 4790.

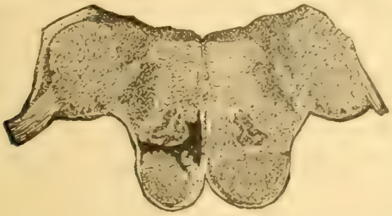
FIG. 4791.

Microscopic Sections through the Hardened Brain.—The brain, after having been hardened by the use of bichromate of potash, Müller's fluid, alcohol, or successively in several of these, is either in whole or in part embedded in a microtome cylinder, with the various media mentioned in another part of this work, and cut into successive thin sections, which may be mounted with or without preliminary staining. Such sections reveal at once the topographical relations of white and gray matter, and the precise extent and minute characters of nerve elements. Placed under a high microscopic power, they often exhibit the precise manner in which the conducting fibrils terminate in the latter. Much depends on the direction in which these sections are made. Those best calculated to familiarize the mind with the bewildering internal labyrinth of the brain are transections made vertical to the brain axis, according to Stilling and Meynert. The human brain as it lies *in situ* has a curved axis. It is, as man stands, nearly horizontal in front of the pons, oblique in and caudad of the pons, and becomes vertical in

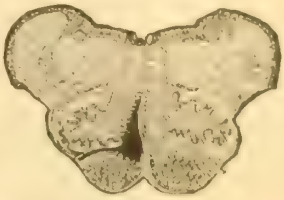
FIG. 4792.

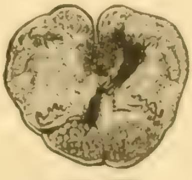
FIG. 4793.

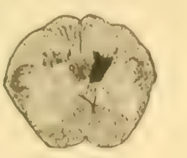
FIG. 4794.

FIGS. 4789-4794.—Secondary Descending Degeneration of the Voluntary Tract, following Hæmorrhagic Lesion in the Pons. Fig. 4789, the site of lesion; 3, cyst representing site of hæmorrhage. Figs. 4790-4794, semi-schematic representation of the [illegible]: 2, at the level of the facial nucleus; [illegible] at level of hypoglossal root; 5, at the [illegible] voluntary tract; 6, just below that level, [illegible] columns of Goll and Burdach.

the caudal part of the oblongata. In order to correct this, the axis is straightened in hardening, an easy operation, requiring the removal of the membranes and the utilizing of the natural softness of the parts. By studying a successive series of such sections the gradual metamorphosis of the cord into the oblongata, the opening of the central canal into the fourth ventricle, its subsequent reduction and closure as the aqueduct, the emerging of the pes from the pons, the relations of most cranial nerve-roots to their nuclei, the topographical relations of the great cerebro-spinal fibre systems, and the apparent origins of many of them, can be advantageously studied. Original investigators employ sections taken in other planes, varying with the special object requiring demonstration. Such sections from the paracentral lobule show the connection of the giant pyramids with medullated [illegible] cortical fibres of the pyramid tract. Sections parallel with the optic tract reveal its relations to the external geniculate and thalamic ganglia. The course of a nerve-tract revealed by other methods may be beautifully demonstrated by the following modification: The brain axis is pared down to within a few lines' depth of the tract in question. The opposite aspect of the brain axis is also pared down, until the segment including the required tract is sufficiently supple to lie flat in the true direction of the latter. The segment is then hardened and cut. By this means the course of the tegmental brachia, from their origin in the ciliary nuclei, through their decussation to their apparent termination in the red nuclei of the tegmentum, can be demonstrated in the actual outlines of an open scissors, to which Stilling happily compared them.

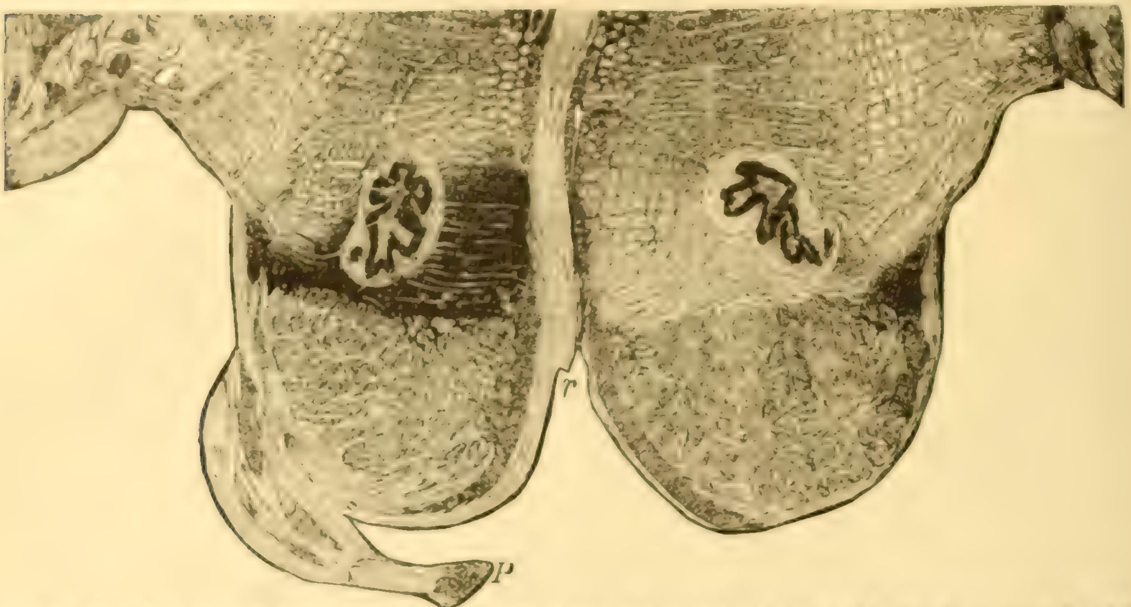

Fig. [illegible].—Peduncle of same Case. Section Level at Posterior Edge of Pons, which is just emerging at the side of the Tegmentum; P, and the Upper End of the Pons [illegible] on both sides. The degenerated [illegible] area of the left side contrasts [illegible] with the right normal area, [illegible] among the pyramid [illegible].

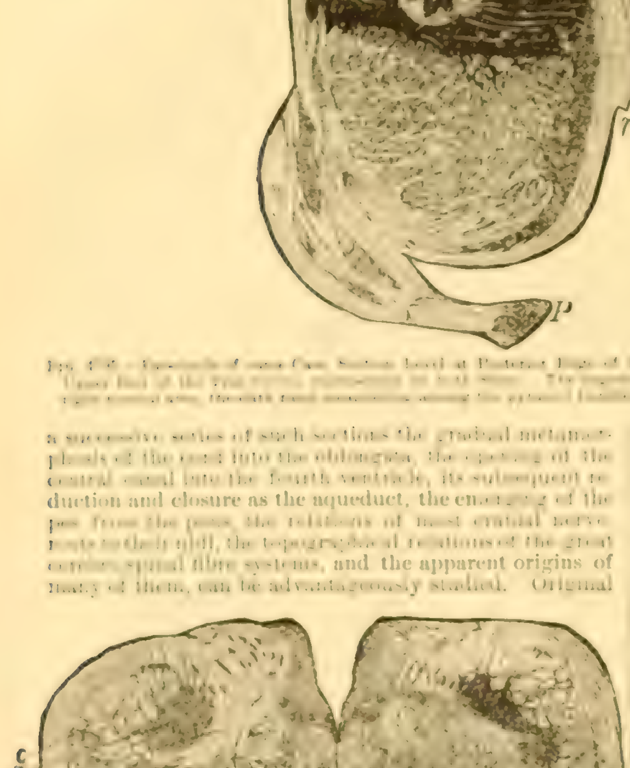

Fig. [illegible].—[illegible] the Oblongata from same Case. Level of [illegible]. D, D, [illegible]

The Developmental Method.—In the lowest forms of nervous systems there is no differentiation of gray and white matter, the nerve fibrils being naked or devoid of the myelin sheath, which in compact accumulations gives to the white substance its opacity and color. What is true of the Invertebrata is also true of the embryonic human brain. Tiedemann found that in the fœtus the white substance of the adult is represented by a translucent grayish-red tissue. Meynert observed that the development of the white color in this tissue is not general and simultaneous, but appears to follow this law, that the tracts of highest function obtain their white color latest. Flechsig elaborated this observation, and showed that each great tract obtains its white color at a definite period of fœtal or infantile life. The pyramid tract attains the color indicating maturity so late, as compared with the surrounding tracts, that it can be discriminated in its entire course by the contrast of its grayish gelatinous look with the white, opaque surrounding field. It is a significant fact that the tracts devoted to sensory transmission precede those devoted to motor conduction; that those transmitting reflex action are developed before those connected with volition; while the latest to mature are the associating fibres which underlie the highest manifestations of the intellect. It is consistent with this that in the reptilian brain these parts only show the medullary white which exhibits it in the early human embryo; while even in the higher [illegible] mammals the differentiation of medullated tracts in the external capsule, the substantia innominata, the subcortical, and subthalamic regions has not advanced

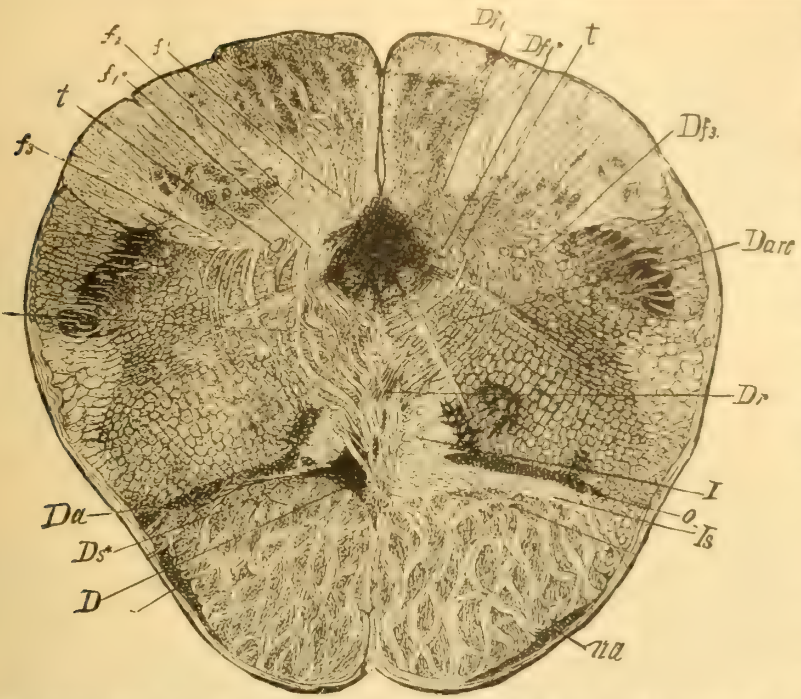

FIG. 4797.—Section nearer Cord, from same. *Darc*, degenerated decussated arched fibres on right side; *Dr*, the same in their decussating course through the raphe; *Df* 1, *Df* 2, *Df* 3, degenerated fibres entering the atrophied nuclei of the columns of Goll and Burdach; *na*, nucleus of arciform fibres.

beyond the point reached in the human brain before birth.

The Study of Secondary Degenerations.—Since the days of Türck and Bouchard it has become recognized that a lesion destroying a nerve-tract in any part of its course induces a change in the entire course of that tract in the direction of its functional transmission. Thus if a motor tract be destroyed in the brain or in the upper part of the spinal cord, there would ensue a descending degeneration; while if a sensory tract were injured in like manner, an ascending (centripetal) degeneration would follow. Secondary degeneration is in a way an inverted analogue of the developmental appearances above described. The immature nerve-tract is discriminated from its surroundings by its grayish color, due to the fact that *it has not yet acquired* myelin. The secondarily degenerated nerve-tract is similarly demarcated from its healthy surroundings by a grayish color, due to *the loss of myelin.* Nearly every observation made by the developmental method has been confirmed by the study of secondary degenerations, and in many cases amplified by it.

In addition to its change in color, due to the disappearance of myelin, the degenerated tract exhibits a marked shrinkage. On making microscopic sections through a brain or cord affected with this lesion the area of the degenerated tract can therefore be recognized, not alone by the color change but by an actual change in outline. In carminized sections the degenerated field is deeply stained, in contrast with the surrounding normal white substance (Figs. 4789–4794); in sections prepared according to the Weigert hæmatoxylin method, it is bleached as contrasted with the latter.

It is not alone the gross outline of the tract that is revealed by such sections. Often the minute relations of its fibres to nerve elements may be discovered through their associated atrophy. In like manner, whenever there is a deviation in the course of its component bundles, wherever these send detachments to other tracts, or run into and comprise constituent elements of ganglia, the fact is revealed by the stain of degeneration in carminized (Figs. 4795–4797), or the bleached appearance, indicating absence of myelin, in Weigert preparations. Just as the geologist determines the course of a coal stratum by the sinking of a few shafts at long distances, so the neuropathologist, on discovering a degenerated patch in the posterior part of the lateral column in the cord, a similar one in the sagittal fibres of the opposite half of the pons, and a lesion in the internal capsule, knows that he has exposed segments of a continuous nerve-tract destroyed by that lesion. He is thus able to demonstrate its cause.

The Study of Natural and Artificial Atrophies of Nerve Centres and Tracts.—The congenital absence of peripheral organs is accompanied by a defective development of the tracts and centres connected with such organs. Thus in persons born without eyes, or microphthalmic, the optic nerve, chiasm, and tracts, the external geniculate body, the anterior pair of the quadrigemina, the pulvinar, and the optic radiations of the corona are atrophied. Observations

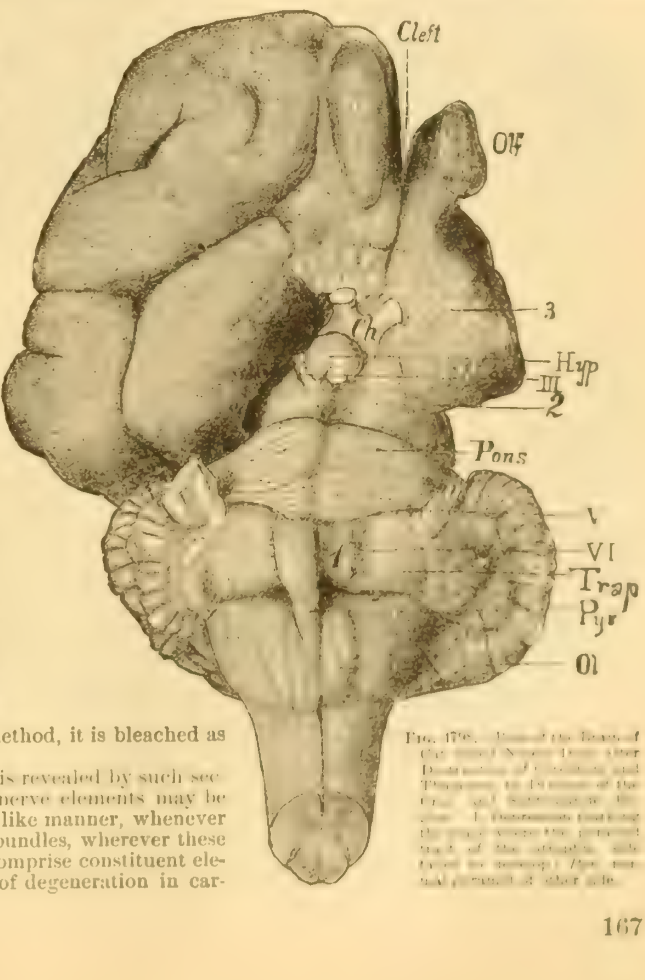

FIG. 4798.—[illegible]

thus made rank with those made by studying secondary degenerations. They have been amplified by the artificial induction of atrophies in the brains of new-born animals. Gudden and his pupils have shown that the course of a nerve-tract, or the connection of a centre with its projected periphery, may be elucidated by the elimination of the latter. If the cochlea be destroyed the auditory tract atrophies. If one extrinsic muscle of the eye be removed, its nidal centre wastes; if the facial nerve be divided, the facial cell-nest diminishes. Further observations in the same direction are made by studying the influence of nerve centres on nerve tracts. If the motor area of the cortex in a new-born animal be destroyed, the entire pyramidal tract is found absent. If the cerebrum be removed, all centrifugal tracts connected with the cerebrum disappear, and if, in addition to the cerebrum, the thalamus be destroyed, the resulting distortion of the brain axis, through the unilateral absence of tegmental and pedal fibre systems is a startling (Figs. 4798–4800) and convincing proof of their dependence on the destroyed ganglia.

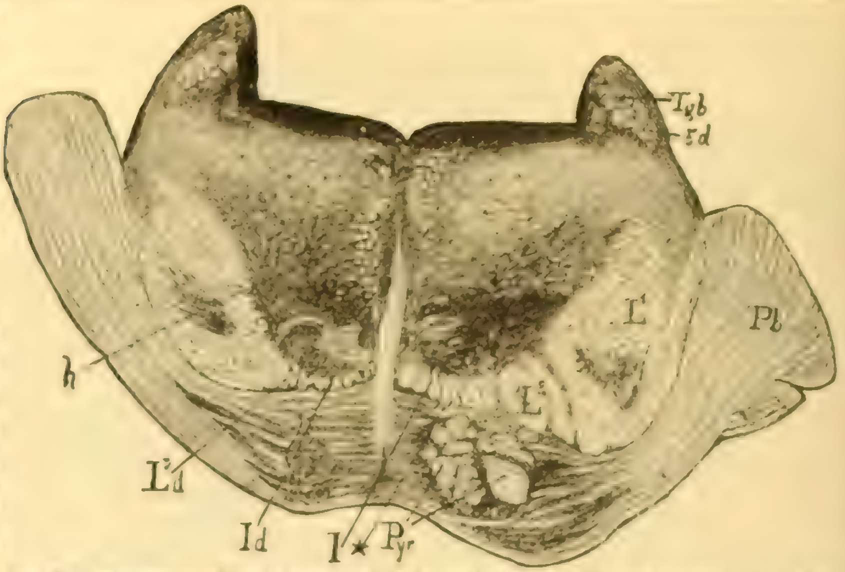

FIG. 4798.—Transection of Pons in Same Case. On normal side Pyr, the healthy pyramid tract; L², the healthy middle segment of lemniscus; I, the healthy intermediary tract. On the atrophied side the pyramid is absent. L²d, the [illegible] middle part of lemniscus; Id, the rudimentary intermediary tract.

6. *The Comparative Method.*—It is noted that animals having peculiarities in the development of peripheral organs have peculiar features of brain structure thereto related. Thus the blind rat of Palestine has rudimentary optic lobes, the microphthalmic mole rudimentary oculo-motor nidi, the elephant with his wonderful proboscis an enormous facial nidus (Fig. 4801). The cetacea, whose hind limbs are wanting, have no column of Goll and no nucleus of that column (Figs. 4802 and 4803). Since prehensile voluntary usage of the extremities is denied them, they have no pyramid tract (Fig. 4804). But in harmony with their exquisite sense of hearing their enormous auditory nerve is accompanied by a powerful trapezium, an enormous acustic division of the lemniscus (Fig. 4804), and overgrown post-optic lobes (Fig. 4805). Such cases constitute natural atrophy, or hypertrophy, experiments as it were, and while not in themselves of exact demonstrative value, furnish valuable and interesting suggestive evidence of the correctness of the results obtained by the other methods detailed. It is seldom that a

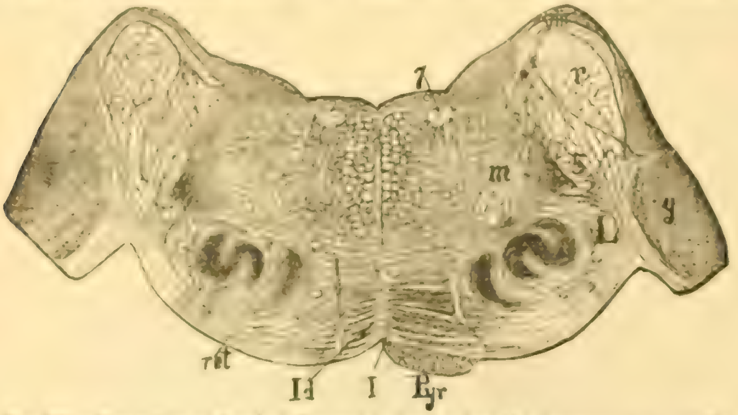

FIG. 4799.—Transection at Level of Trapezium, showing how the Asymmetry is gradually Diminished as it [illegible] Caudad. The lettering has the same signification as in Fig. 4798.

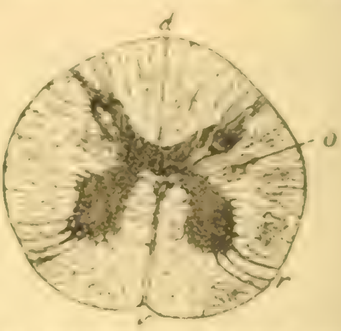

FIG. 4802.—Transection of Cord at Upper Cervical Level of a Porpoise. d, Posterior [illegible]; the [illegible] [illegible] is absent, as there is no [illegible] of [illegible].

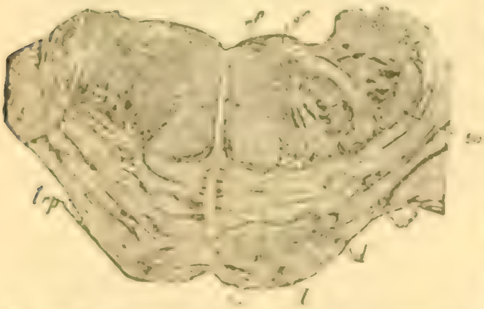

FIG. 4801.—Transection of Pons of Elephant. Natural Size. nf, Facial nidus [illegible].

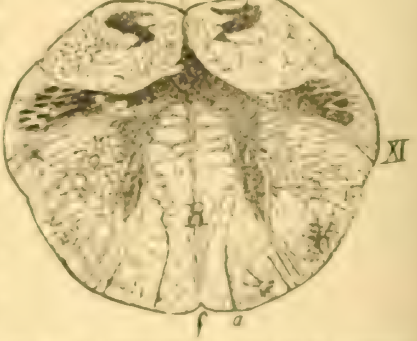

FIG. 4803.—Transection of Caudal Part of Oblongata. n, Nucleus of [illegible]; [illegible] XI, accessory.

valuable result is obtained by the exclusive pursuit of a single method. To determine the significance of a given ganglion its minute structure must first be studied by methods strictly histological. Its relation to neighboring nerve-tracts, if not determinable by direct observation, may be demonstrated by studying the secondary tract degeneration ensuing after its disease in man, or the atrophy following its elimination in lower animals. The latter, in its turn, involves a correct homologization by comparative anatomy.

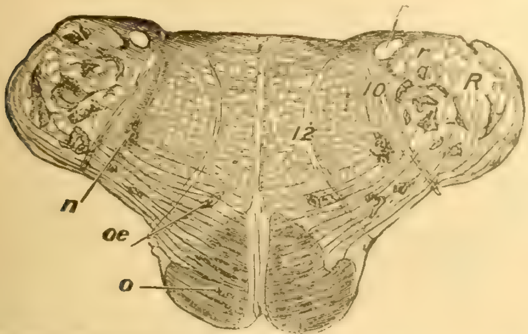

FIG. 4804.—Transection through Oblongata of Dolphin more Cephalad than Fig. 4803. *o*, Olivary nucleus, nearly in contact with its fellow, owing to absence of pyramids.

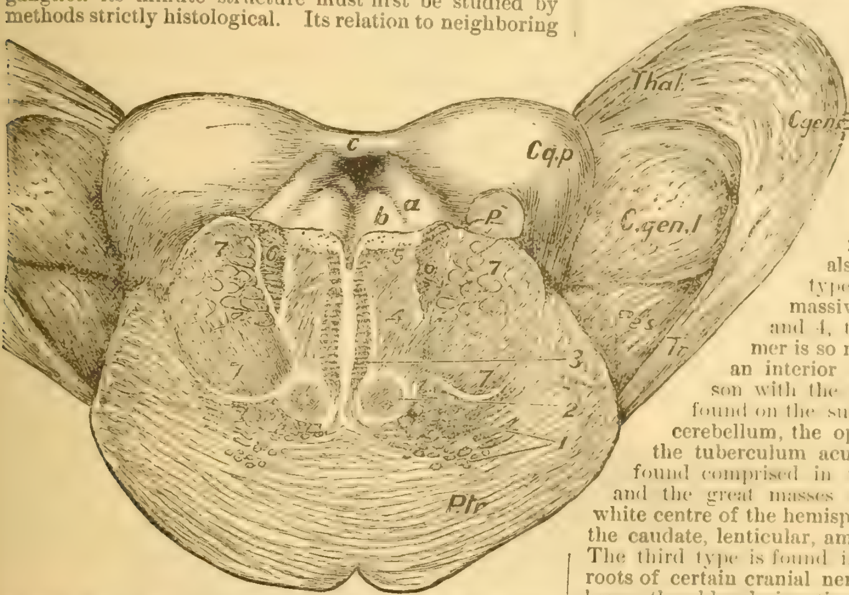

FIG. 4805.—Caudal Face of Dolphin's Isthmus. *Cq.p*, Postoptic lobes; *C.gen.I*, inner geniculate body; 7, hypertrophied (auditory) division of lemniscus.

To the eye the chief difference found in the component elements entering into brain structure is one of color. *White* (alba) and colored tissues, the latter conventionally designated as *gray substance* (cinerea), are seen to alternate in a definite way. It must not be supposed that the distinction between the two is a sharp one. While the white substance is exclusively conducting substance, the gray is not exclusively ganglionic, for the former encroaches on the latter. In some situations, as in the so-called vesicular columns of Clarke, the admixture of white or myelinic nerve fibres is so great that the ganglionic substance is rather white than gray. Even in the cerebral cortex and the anterior horns of the spinal gray the admixture of myelinic fibres is considerable. The physiological transition of conducting to "receiving" or "evolving" substance must therefore be located within the confines of the ganglionic substance, and not at its contact line with the white. The reaction of gray matter is slightly acid, as is shown by injecting the flavopurpurate of sodium in the veins of a living animal. The dark red solution, is changed to a golden yellow hue by the slightest excess of acid, and all the gray substances of the brain and cord, in an animal thus injected, are found of that color. Its natural color is due to four factors: 1, translucency; 2, degree of capillary injection; 3, amount and color of pigment in the nerve elements; 4, admixture of white substance. In thin slices it is transparent and almost colorless. When injected with arterial blood it presents a rosy hue (cortex, red nucleus of the tegmentum), when pigmented, various shades of yellow, *café au lait* (nucleus of Luys), dark gray (ala cinerea), deep bluish gray (locus cæruleus), or black (substantia nigra). An admixture of medullated nerve fibres causes it to present white streaks (the lines of Vicq d'Azyr and of Baillarger), or give it as a whole the appearance of white matter (columns of Clarke).

The specific gravity of the cortical gray is 1.0206–1.0239, of the great ganglia 1.0334–1.0346, of the cerebellum and mesencephalon 1.0479–1.0584, and of the white substances 1.0273–1.0289.

It is to the peculiar mutual relation of white and gray substance that the various cerebral provinces owe their optically characteristic features. Three well-marked types of ganglionic structure are generally recognized; a fourth, less well studied, is also to be distinguished. These types are, 1, the cortical; 2, the massive ganglionic; 3, the nidal; and 4, the intrafascicular. The former is so named because its situation on an interior white centre invites comparison with the rind (cortex) of a fruit. It is found on the surface of the cerebrum, of the cerebellum, the optic and olfactory lobes, and the tuberculum acusticum. The second type is found comprised in the diencephalon (thalamus) and the great masses which are embedded in the white centre of the hemisphere like so many nuggets—the caudate, lenticular, amygdalar, and claustral nuclei. The third type is found in direct connection with the roots of certain cranial nerves and comprises cell nests, hence the older designation of nuclear, and the one here proposed, nidal type. The fourth is found either as a diffuse admixture in the course of nerve strands, or in compact accumulations to which these strands occupy definite relations. They are regarded as terminal, as interrupting or as condensing stations for the latter. The club- and flame-shaped nuclei of the columns of Goll and Burdach, the concentric hollow spheroids of the red nu-

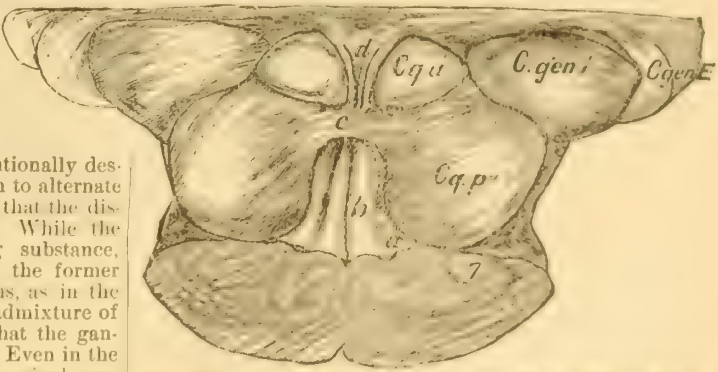

FIG. 4806.—Dorsal View of the same Segment. *Cq.a*, optic lobes; other designations as in Fig. 4805.

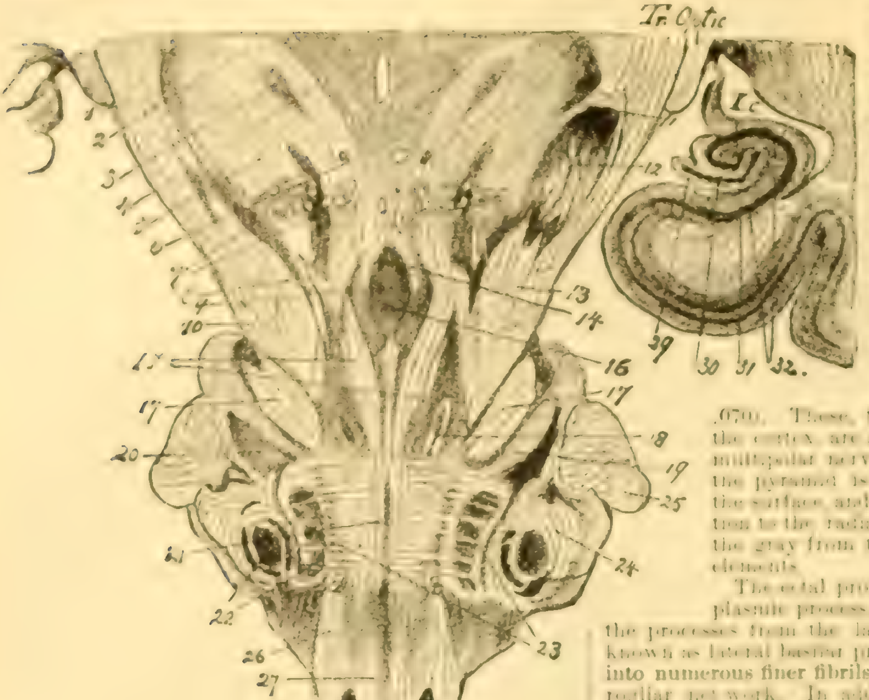

FIG. 4807.—Transverse Section through Isthmus of Dog, showing the [illegible]

cleus of the tegmentum, the stratiform nuclei of the pons, the dentated volutes of the olive, cerebellum, and trapezium, the laminæ of the external geniculate body, and the basket-work intercalations of the reticular and lemniscus fields belong to this type. It is to these various dispositions of gray matter, and the related interdigitating with white tracts that sections of the crus and oblongata owe their beautiful and characteristic marbling (Figs. 4807 and 4808).

The cerebral cortex covers the distal face of the gyri and the walls of the septum lucidum, presenting various degrees of [illegible] sixth of an inch. It is thinner at the bases than at the apices of the gyri. In the fresh brain it is translucent, and exhibits a stratiform arrangement; the gray, [illegible] which is darker in the old than in the young, [illegible] than in the white [illegible], being interrupted by pale opaque zones. These are found on minute examination to consist of a predominating proportion of myelinic nerve fibres. There is a bluish-white zone, fading more or less into the adjacent gray, over the greater part of the cerebral surface (Baillarger's stria), and a distinctly defined set in the occipital lobe (stria of Gennari or Vicq d'Azyr). It is in the area characterized by the four-layer, comprising the entire frontal lobe, the Rolandic region, the apex of the temporal and those parts of the parietal lobe which abut on the Rolandic region, that the typical four* strata are distinguished under the microscope. Passing from the pia surface to the white substance they are as follows: (1) ependymal layer, barren of nerve elements but rich in medullated nerve fibres, which chiefly run parallel to the surface of the gyrus. Its thickness is 0.2-0.275 mm. (2) Comprising more than half the thickness of the cortex, a layer of pyramidal elements, very numerous, small at the confines of the barren layer (.004-.010), larger as they lie deeper (.020-.070). These, the characteristic elements of the cortex, are a modification of the ordinary multipolar nerve element. The long axis of the pyramid is almost uniformly vertical to the surface, and consequently parallel in direction to the radial nerve fibres which penetrate the gray from the white, as if to reach these elements.

The distal prolongation is a branched protoplasmic process, known as the apex process, the processes from the lateral angles of the base are known as lateral basilar processes. Both these break up into numerous finer fibrils, which contribute to the neuroglia network. In addition the larger cells have a process which, as a rule, proceeding from the axis of the basilar part of the cell, remains unbranched, becomes covered with myelin, and traversing the intervening gray reaches the white substance. Such cells have therefore the same relation to fibres of the white substance which the multipolar nerve cells of the anterior horn of the spinal gray have to the anterior roots of the spinal nerves. (3) The layer of pyramids is followed by the layer of granules. These are small nerve elements (.007-.010 mm.), angular in shape, with very fine processes and

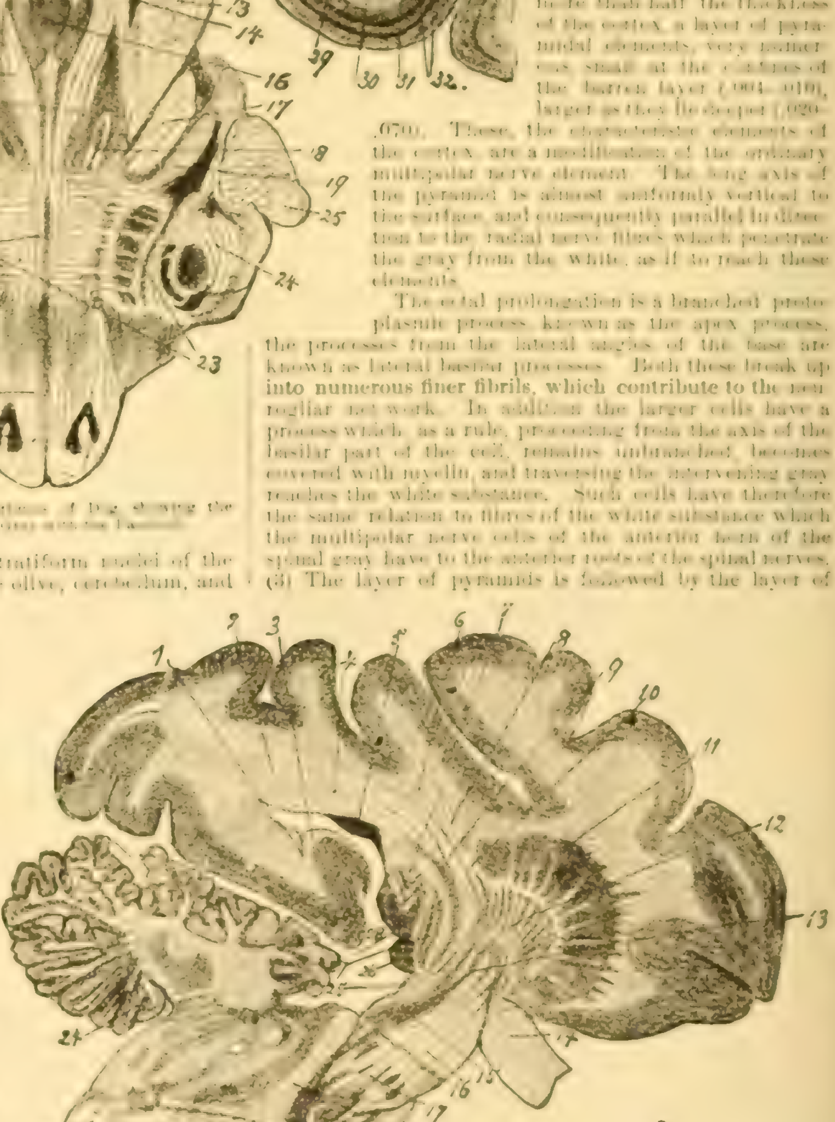

FIG. 4808.—Section in Sagittal Direction, the Plane Extending from Dorsomesal to Ventrolateral, of a [illegible]

lying closely crowded. Inasmuch as the medullated fibres which leave the white substance to reach the layer of pyramids traverse the layer of granules in groups, it follows that the granules do not everywhere appear as a continuous stratum, but seem in section to be broken up into irregular parallel columns. The pyramids do not cease abruptly at the ectal boundary of the layer of granules, but encroach upon it, usually lying among the medullated fibres just mentioned. The pyramids thus intruding, while not as numerous as in the layer named after them, are very large, and in one particular region of the cortex attain the largest dimensions found in the human nervous system. They are the giant pyramids of Betz. The largest are found in nests or rows in the cortex of the paracentral lobule (.050 mm. wide, .125 mm. long). They are slightly smaller toward the middle of the pre- and postcentral gyri, still further diminishing toward the Sylvian region. In distribution they correspond to the cortical motor fields, and it is a suggestive fact that the largest are found in the focus of the leg centre, the next in size in the focus of the arm centre, and the smallest in the facial and hypoglossal centres, thus corresponding to the relative size of the innervated muscular masses. The layer nearest the white substance is marked by the intrusion of many nerve fibres running near the boundary between the gray and white substance. At the floor and sides of the fissures their course is parallel to the cortical surface.

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* [illegible] "small" and "large" [illegible]

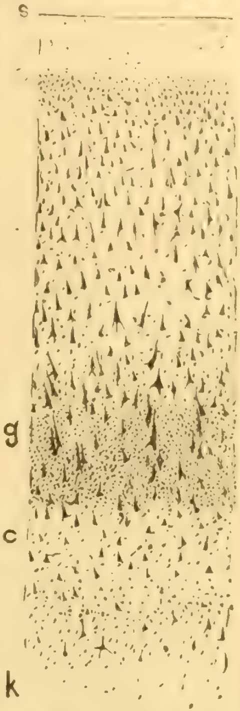

FIG. 4809. Vertical Section through Cortex of Middle Frontal Gyrus, at its Apex. Elements only represented. *s–e*, Ependymal or barren layer; *e–g*, layer of pyramids; *g–c*, layer of granules with interspersed larger pyramids; *c–k*, ill-defined cells, transition to spindle shape; *k*, white substance.

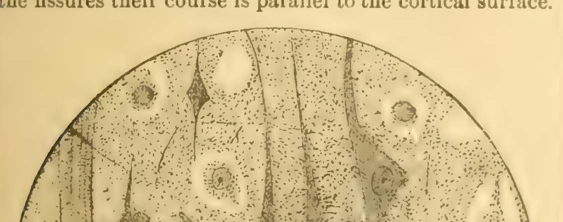

FIG. 4810.—Large Pyramids from Cortex of Imbecile, showing a Basilar Process proceeding from the Middle of the Base of One, and from the Lateral Angle of another of these Elements.

But at the apices or free part of the gyri these *tangential* fibres verge toward the surface. From this results a peculiar disposition of the nerve elements of this stratum. They are fusiform, connected with the fibres named, at one end of their attenuated bodies (.003–.010 wide, .020–.035 long). Hence they lie parallel to the fibres near and among which they are scattered, and are parallel to the cortical surface at the base and sides of the sulci, but vertical to it at the apices. Meynert regards these fusiform or spindle cells as "association cells," and from their alleged preponderance in the claustrum, which he considers to be the differentiated and isolated deepest layer of the cortex of the insula, denominates them as comprising the "claustrum formation."

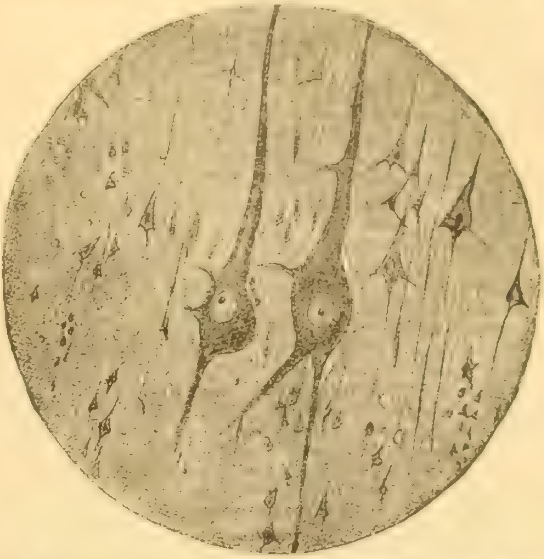

FIG. 4811.—Two Giant Pyramids from Paracentral Lobule of Man. × 100.

From the above type of cortical structure there are several local variations. The most important are found in the occipital lobe and the cornu ammonis. Briefly, the occipital type may be described as presenting the following points of correspondence or contrast with the fronto-parietal type: (1) The barren layer is present in both; (2) the layer of pyramids is present, but thinner in the occipital lobe; (3) the layer of granules is hypertrophied and subdivided into three strata by two intercalated zones, barren in elements (a few of large dimen

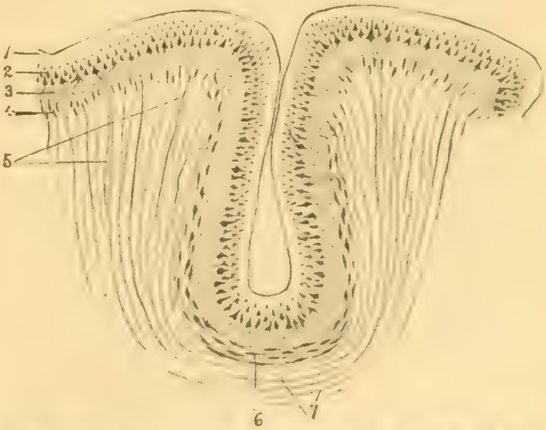

FIG. 4812.—Diagram of a Section Vertical to the Surface of Two Adjoining Gyri. F, base of intervening fissure; 1, barren layer; 2, layer of pyramids; 3, granule layer; 4, 6, layer of spindles, vertical to surface at 4, parallel to surface at 6; 5, projection fibres of white substance, directly connected with large pyramids or [illegible] in the cortical [illegible] maze; 7, tangential (association) fibres.

[illegible] are found such known as "axillary" [illegible] fibrils in medullary nerve fibres. It is these white striae which, to the naked eye, appear to form a single sharply marked streak, particularly distinct at the calcarine fissure, the white lines of Vicq d'Azyr;* as the layer of spindles is present as before. Thus by the subdivision of the one granular layer of the frontal cortex into three granular and two intergranular layers, the occipital cortex presents eight strata: 1, the barren layer; 2, a narrow stratum of pyramids; 3, the ectal granular layer; 4, the ectal intergranular layer; 5, the intermediate granular layer; 6, the ental intergranular layer; 7, the ental granular layer; 8, the stratum of spindles.

In the cornu ammonis the pyramids are very numerous, closely crowded, and much elongated. To understand the significance of this peculiar [illegible] cortical structure, let the student imagine the cortex enfolded on its pyramidal layer, and that layer rolled in such a way that a transection elsewhere would show an S-shaped curve. The position of this S (subiculum) must be so understood as if two of opposite sides faced each other, thus: S Ƨ (Fig. 891, 52). The upper half of the S faces the ventricle with its convex head forming the prominence of the hippocampus; it is here covered by white substance, the alveus. The ventral end of the S, falling out in the ventricle with a free cortical surface, shows a remarkable hypertrophy of the white fibres in the barren layer, which intrude like a thin sheet between the upper convexity of the S and a remarkable band which bears the relation of a "[illegible]" to the cornu—the fascia dentata.

The fascia dentata is an amorphous [illegible] aggregate of the cornu ammonis, and just as the latter is the temporal extremity of a ring-shaped convolution surrounding the callosum, so the fascia dentata is the temporal development of a (human) rudimentary gyrus, running parallel with the gyrus fornicatus, constituting the longitudinal grayish striae (medial nerves of Lancisi) interposed between the edge of the gyrus fornicatus and the callosum. Its cells are small, closely crowded in two or three rows. Their protoplasmic processes run peripheral. The nerve fibres from the cornu ammonis and fascia dentata are collected to a sharp-edged ridge, gradually rising higher as new additions are made to its substance, which is the fimbria. Its main direct source of fibre supply is the alveus; its continued prolongation is the fornix.

By many the olfactory bulb is regarded as a part of the cerebral cortex. In reality it is merely analogous in texture, and represents an independent brain segment (see Centres of Special Sense).

The cortex of embryos between the third and fifth months, when hardened, already shows that peculiar fracture line characteristic of the adult cortex, the cleavage being as if in fine parallel fibrils vertical to the surface. This indicates some disposition, because of the ultimate arrangement of cell rows, entering nerve fibres and blood vessels. The first distinct elements are observed in the second layer at about the sixth month. The granules of the third layer appear at the seventh month. Generally speaking, the development of the gray and the cortical elements [illegible]. In the embryonic human brain only the cortical layer is represented; then the white fibres develop and gradually obtain that preponderating mass characteristic of the mature brain, in their order of functional dignity, the [illegible] projecta being the latest to mature.

The ganglia embedded in the interior white matter of each hemisphere are the caudatum, lenticularis, amygdala, and claustrum. Of these but one, the caudatum, has a free surface at the floor of the lateral ventricle; the others are embedded in the white matter of the cerebral interior, or fuse with the cortex. Their shape and connection is intimately allied with the growth and shape of the cortical mantle, to which they are often regarded as bearing the relation of subordinate, subcortical, centres.

The lenticularis resembles an irregular, triangular pyramid, lying on its side. Its base is parallel and near to the cortical expanse of the insula and of about the same extent. The three sides of this pyramid are an upper, sloping caudad, an anterior, sloping [illegible], a lower, sloping [illegible]. All these sides attenuate toward the mesal plane, so that they unite in an apex which is directed toward the [illegible] (Fig. 898, 11 and 17).

If the pyramid just described be regarded as an axis of rotation for the caudatum, the relations of the latter are readily understood. Except at the base of the brain and a number of anastomoses in the anterior division of the internal capsule, the caudatum is a free ring circling around the lenticularis. As it is nearest to the frontal portion, becomes attenuated caudad, and the attenuated part is reflected on itself to run along the roof of the inferior horn, whereas the remainder lies at the floor of the anterior horn and body of the lateral ventricle; the cephalic part is called the head, the caudal part the tail.

The claustrum is a thin expanse interpolated between the cortex of the insula and the base of the lenticularis. It also corresponds in extent nearly with the extent of the insula. The streak of white matter separating it from the lenticularis is known as the external capsule; the one separating it from the insular cortex is unnamed.

The nucleus amygdalae is an irregular lump of gray matter situated in the apex of the temporal lobe, between it and the apex of the inferior ventricular horn. It lies ventrad of the lenticularis.

As distinct as all these gray masses appear in sections taken in certain planes, there is a common ground on which they meet, with which they fuse, through which they are indirectly united, and by which their embryonic derivation from a common origin is proven. This is the gray matter of the anterior perforated space. In front this fuses with the lenticularis, which in part rests on it; it penetrates between the latter and the amygdala and unites with a broad spur from the claustrum. With the caudatum it does not directly unite, but as the mesal [illegible] of the caput caudati fuses with the lenticularis they are indirectly continuous.

The caudatum presents a ventricular and a capsular surface. The ventricular is lined by an ependyma so dense that it may be separated and demonstrated as a coarse membrane. The capsular face is irregular, numerous strands of capsule fibres entering it obliquely, so that on transection they appear as white spots, on sagittal sections as streaks. They extend to about half-way through the ganglion, and there split up into finer and finer bundles which become lost to the naked eye. Two kinds of elements are found in its reddish gray matter. A larger, intermediate to a star shape and the pyramid type (20–30 μ); they have numerous protoplasmic and an axis cylinder process. The smaller variety (15–20 μ) have only the former. In addition a large number of nuclear bodies surrounded by apparently granular protoplasm contained in vesicular spaces, whose nature is disputed, as well as glia cells, are found in this ganglion.

The lenticularis is composed of three* concentric segments, the dividing line being laminae of medullary fibres which run parallel to its ectal face. The subdivisions are known as [illegible]; the most ectal is specially designated the putamen. It is of a deeper reddish gray color than the two mesal divisions, which together are termed globus pallidus. The aforenamed streaks are joined by lesser streaks emerging from within the putamen, or traversing the [illegible] of the globus pallidus; from this a very characteristic striated appearance results. The minute structure of the lenticularis corresponds to that of the caudatum, the proportion of large cells being greater. The amygdala is regarded as a hypertrophied layer of the temporal cortex, which has become nearly isolated from its cortical connection by intruding white matter. Except that streaks of white matter run irregularly into and through it, it has the structure of cortical substance. The same applies to the claustrum, which is commonly regarded as the isolated spindle-cell stratum of the insular cortex, although neither embryological nor comparative anatomical observation support that view.

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* These are sometimes much [illegible] in Vicq d'Azyr [illegible]

* Four and even five layers have been observed by the author, the supernumerary ones lying within the globus pallidus.

White Substance of the Hemispheres.—The entire space intervening between the cortex cerebri, the cavity of the lateral ventricles, and the great ganglia at the base, is filled out by white substance; the greater part of the cerebral mass being thus composed of a mass of myelinic nerve fibres. These connect the ganglionic elements of the cortex with other parts of the nervous system. Some pass from the cortex about the calcarine fissure and apex of the occipital lobe to the external geniculate body and a special region of the thalamus, both of these being in turn connected with the optic tracts. Another set passes into the olfactory tracts. Still another unites the cerebral hemisphere to the cerebellum. Some traverse the entire length of the cerebro-spinal axis, placing every segment of the spinal gray in relation with a definite part of the cortical area. Others remain intracerebral in every part of their course, uniting one area of the cortex with another, crossing the median line—like the corpus callosum—to associate the two hemispheres, or finally establishing a functional bond of union between the cortex and the great ganglia.

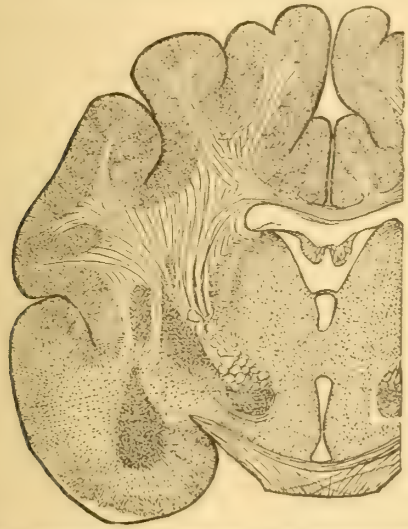

FIG. 4813.—Cross-section of a Cat's Brain. The gray substance, cortical and ganglionic, represented by dots, the white by lines, indicating the main directions of the fibres.

In the fresh brain this white substance may be compared to an irregularly shaped kernel, of which the cortex is the shell. Where the cortex is raised in folds, the white substance enters it like a ridge. The union between the two is intimate; fibres enter the lower strata of the cortex to connect with the axis cylinder processes of the larger pyramidal bodies, others appear to run nearly to the surface, and some are inseparable from the plexus of intracortical nerve fibrils. It is because of the preponderating development in man of those tracts which place the lower centres under the cortical dominion, and above all of those which serve to establish association of different cortical districts, that relatively to the gray substance the white kernel of the hemispheres appears proportionately larger than in other animals (Figs. 4813, 4814, and 4815).

As a whole the fibres of the white substance tend to converge, like the sticks in the handle of a fan, toward the base of the cerebrum, where the crus carries off a large proportion of them, notably those which traversed the *internal capsule*. The latter is a detachment of the corona radiata, caught as it were between the basal ganglia. A flatwise section of the cerebrum shows it to be bent, very much as a leg is bent on the thigh, with the knee mesad. The anterior or caudo-lenticular division is confined between the parallel ectal border of the caudatum and the cephalo-mesal border of the lenticularis. The genu receives the apex of the lenticularis in its hollow, while the posterior or thalamo-lenticular division lies between the ectal border of the thalamus and the caudo-mesal border of the lenticularis. In front it merges with the white interior of the frontal, behind with that of the occipital, above with that of the Rolandic opercular and parietal organs, from all of which the fibres of the corona radiata pass into it. Some traverse it and enter the crus, others enter the great ganglia on its border, contributions being received to make up for their desertion by fibres which leave the great ganglia to join its columns.* We must therefore distinguish

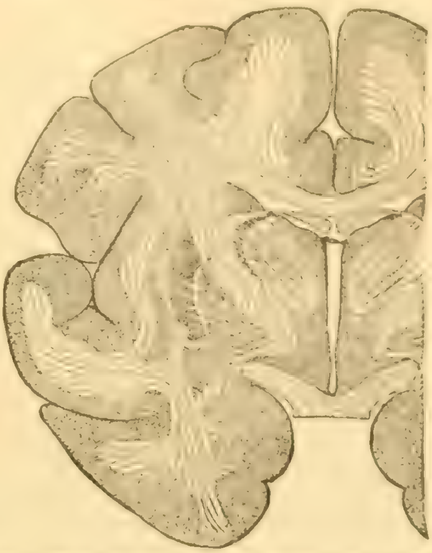

FIG. 4814.—Ditto of Baboon. The white substance is more voluminous, the demarcation of the lenticular and other nuclei by intruding fibres is more distinct.

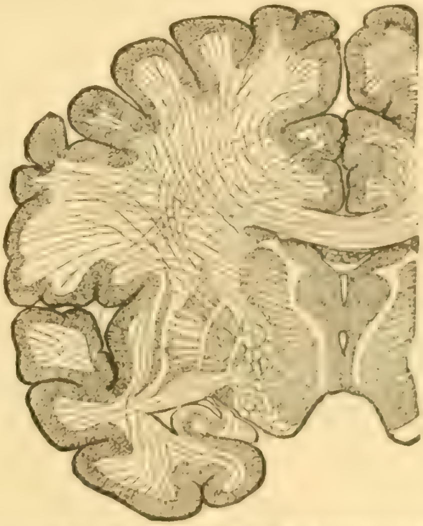

FIG. 4815.—Ditto of Man. The commissural and associating fibres appear to make up the great bulk of the white substance.

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* V. Marchi claims that [illegible] in the capsule itself.

the following cardinal fibre systems in the white matter of the hemispheres: 1. Projecting systems which unite the cortex to lower centres. These are classified according to their length: (a) The longest direct motor tracts (pyramids to the body), which pass to the spinal gray; (b) those which pass to the pons—these two sets must traverse the capsule and crus, constituting their most important ingredients; (c) tracts uniting the cortex to the caudate, lenticular, subthalamic, thalamic, geniculate, and other nuclei—they traverse the capsule in large part, but do not enter the crus proper; (d) tracts which connect the great ganglia with each other (disputed in some).

In addition to these tracts there is one structure made up of medullated fibres whose relations are unsettled. This consists of a narrow white streak intercalated between the thalamus and caudatum at the ventricular floor. In color it resembles translucent whalebone, owing to a vein which passes along and under it. It is the *stria cornea*. It follows the inflection ventral of the tail of the caudatum, and there its fibres radiate into the nucleus amygdalæ. The terminus of its cephalic end is unknown, but it is certain that it does not, as older authors claimed, join the fornix, notwithstanding that—in the most cephalic course of its fibres.

Aside from the projecting fibres which form the corona radiata and converge from the interior of the cortical expanse to the central ganglia and capsule, the interior white of the hemisphere contains fibre tracts which unite various provinces of the cortex with each other. Two classes of the latter may be distinguished: the one arches from gyrus to gyrus, narrowly skirting the cortex at the base of the sulci (fibræ propriæ); the others unite distant cortical areas with each other. Such are a *fronto-occipital associating bundle*, forming the *tapetum ventrally*, uniting the cortex of the frontal with that of the occipital lobe (fasciculus longitudinalis superior). A similar bundle unites the apex of the temporal with the occipital lobe (*fasciculus longitudinalis inferior*). Other bundles have been described; their existence is not established. The labyrinth of projecting and associating fibres derived from and proper to each hemisphere is further complicated by the commissural systems, which unite the opposite cerebral hemispheres in such a way that their white matter constitutes an anatomical continuity. These are the callosum and the precommissura.

The *callosum* is composed of transverse fibres which penetrate the white interior of each hemisphere; intermingling with the fibres of the superior longitudinal associating fasciculus they are ultimately lost in the labyrinth of subcortical and projecting tracts. That they unite symmetrical brain provinces (i.e., the right occipital to the left occipital, the right frontal to the left frontal, and the right Rolandic to the left Rolandic cortices) is the prevailing opinion, and harmonizes with pathological observations.

The *precommissura* is composed of white substance. Its fibres are transverse and commissural. They are of two classes. The anterior and smaller division unites the two olfactory lobes; the posterior and larger is a commissure of the temporal lobes. In its course to the temporal lobe this division forms a beautifully distinct fasciculus which perforates the lenticula. The olfactory division passes into the ventral part of the olfactory tract and detaches a small portion to the orbital face of the frontal lobe.

The *fornix* is the equivalent of the corona radiata for that part of the cortex which undergoes metamorphoses into the fornix, callosum, and fascia dentata. It should be regarded as distinct from its fellow of the opposite side, for the so-called lyra is properly commissural. Each fornix, then, is the projecting bundle of the gyrus hippocampi, from which it collects the medullated nerve fibres through the fimbria. Having arched over under the callosum, each crus of the fornix, passing caudal of the precommissura, circles ventral of the porta (Monro), and plunges into the central gray of the third ventricle, forming a visible prominence thereby. It then runs caudo-ventrad, insinuating itself between the bundle of Vicq d'Azyr and the lateral ganglion of the mammillary body. Dorsad of the medial ganglion of the mammillary body one division of the fornix decussates; the other's termination is unknown.

Through the fornix, as well as more directly by the attachment of the posterior part of the capsule on the thalamus, the transition from the hemispheres to the diencephalon is established. The chief ganglion of this segment is the *thalamus*. The cells of this nucleus are scattered irregularly through the gray portions; larger forms of the multipolar variety, and presenting axis-cylinder processes, predominate. In all other essential respects it corresponds to the caudatum. It differs from it in being subdivided into a number of distinct nuclei. Of these three are universally recognized. The largest are the ental and ectal; they are separated from each other by a white layer (lamina medullaris interna) which runs parallel to the wall of the third ventricle for its greater length; posteriorly it runs mesal, overlapped by the ectal nucleus. Numerous offshoots run from it through the ectal nucleus, parallel to its dorsal surface (Fig. 4816, 5). In the anterior half of the thalamus the inner medullary lamina subdivides into two branches, thus permitting the intrusion of a third or anterior (cephalic) nucleus between the two main nuclei. This constitutes a distinct elevation on the dorsal face of the thalamus and on a small scale repeats the shape of the dorsal aspect of the caudatum, its rounded head being cephalic, its attenuated part caudal. The pulvinar is in reality but a hypertrophied extension of the ectal thalamic nucleus. Both are covered by a *stratum zonale*, a layer of medullated fibres spread out over the dorsal and posterior, in fact the entire free face of the thalamus, and in large part nothing more nor less than an expansion of the optic tract. At the contact plane of the ectal thalamic nucleus and the white matter of the hemisphere a peculiar appearance results from the interdigitation of thalamic and cerebral fibres, and their inclusion of thalamic gray substance in a rather regular pattern; this is the lattice work stratum of the thalamus (*stratum reticulatum*). A compact layer on its mesal aspect, more distinct in lower animals than man, is called the ental medullary lamina.

As the optic tract courses up and behind the slope of the pulvinar it is intimately connected with a ganglion which is by some regarded as an accessory ganglion proper to the optic nerve, but according to most modern researches is a derivation of the thalamus. This is the *external geniculate body* (*pregeniculum*). It is characterized by the regular alternation of deeply gray and white lamina. The former are thicker, the latter thinner and apparently continuous with the optic tract fibres. The nerve cells in the gray substance are large (30-50 μ), multipolar, and pigmented.

A white streak of medullated fibres, nearly corresponding to the attachment of the tela choroidea (tænia thalami), separates the free surface of the thalamus with its characteristic zonal stratum, from the gray matter lining the third ventricle. The latter is not properly a ganglion of the thalamus, but separately designated "*central gray of the third ventricle*." It extends from the porta (Monro) along the side of the ventricle, lines its floor (lamina terminalis, tuber cinereum, posterior perforated region), and by its fusion forms the so-called commissura mollis (medi-commissura).

The eminence on either side of the postcommissura known as the habena includes the *ganglion habenulæ*, which is composed of small angular nerve cells and numerous granules. It apparently constitutes a terminal point for three sets of fibres: 1, Those from Meynert's bundle; 2, the tænia thalami; 3, the habena proper.

Each of the two symmetrical eminences known as the *corpora mammillaria* incorporates three ganglia.* One of these, the lateral, is applied against the two medial ganglia, so as to represent a crescent on cross-section. Its cells are large. The so-called peduncle of the mammillary body, which in man is difficult of identification, is connected with it. The other two ganglia are situated cephalo-dorsad and ventro-caudad with relation to each other. The former (*Gudden's ganglion*) is connected with the tegmental bundle, also named after him, and which can be traced mesad of Meynert's bundle to a group of cells situated ventrad of the posterior longitudinal fasciculus of the tegmentum and caudad of the great tegmental decussation. The ventro-caudal ganglion is in like manner connected with the *bundle of Vicq d'Azyr*, a fibre-tract formerly confounded with the fornix, now known to be distinct from it, and which runs cephalodorsad to terminate in the anterior tubercle of the thalamus. It is the spreading out on the surface of these two medial ganglia, by the somewhat interwoven fibres of Gudden's and Vicq d'Azyr's bundles, that forms the rounded medullary capsule, uniting them in the spurious unity of the corpora mammillaria.

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* Not recognized in man.

The *hypophysis* (pituitary body) is composed of two divisions, distinct in structure, as they are in embryonic origin. The part directly continuous with the infundibulum contains a cavity originally derived from the third ventricle, its walls have a nervous structure, containing small nerve cells, nerve fibres, and neuroglia. It is invaginated, as it were, into the larger or epithelial division, which contains epithelial tubes, dovetailing with large blood-vessels from the pia. They contain a special pigment, and appear to secrete a colloid material which is often present in large masses.

The *epiphysis* (pineal gland) is not regarded as an important neural ingredient of the brain. Indeed, its nervous nature has been disputed. It unquestionably includes some nerve-fibres and a few scattered nerve cells. The chief interest attaching to its study lies in its phylogenetic relations. It is generally believed to be a rudimentary relic, representing a cyclopean eye: the primitive eye of some extinct ancestral vertebrate. In some living lizards (Hatteria) the epiphysis has a structure closely resembling that of a molluscan eye, even embodying a crystalline lens and a pigmented and unpigmented (retinal) epithelial stratum. In mammals a neural and a glandular portion are distinguished. The latter includes the so-called brain-sand (acervulus), which is a product of the epithelial secretions.

The posterior perforated space (area intercruralis) is the surface development of the *interpeduncular ganglion*, a gray mass of much reduced dimensions in man, but very large in the rodentia. It is shaped on cross-section like an inverted letter T, the vertical branch merging dorsad with the median raphe. Its cells resemble those of the ganglion habenulæ, but are less angular. Meynert's bundle connects it with the ganglion habenulæ.

In addition to the ganglia of the thalamus and of the eminences visible on the ventral and dorsal faces of the diencephalon, large and important intercalar nuclei are exposed on transection of this segment. The more important of these are the body of Luys, the ganglion of Soemmering, and the red nucleus of the tegmentum. The *ganglion of Soemmering* (*substantia nigra*) is the most readily identifiable. It is exposed on cross sections through the level of the corpora quadrigemina and crura cerebri. In its greatest extent it represents a crescentic interpolation between the pes pedunculi and the tegmentum. Mesad it nearly touches its fellow of the opposite side, being separated by the rudimentary interpeduncular ganglion. Its ventral face sends numerous ramifying prolongations among the fasciculi of the pes (Fig. 4816, 13). The cells are large, multipolar, their bodies approaching the fusiform or angular in outline. In man, and man alone,* they are characterized by a pigment, which varies from a deep brown to an absolute black in color. This gives to the entire ganglion its black color so sharply contrasting with the surrounding tissues. It is not pigmented in the new born, of a pale brown in young persons, and increases in blackness with age.

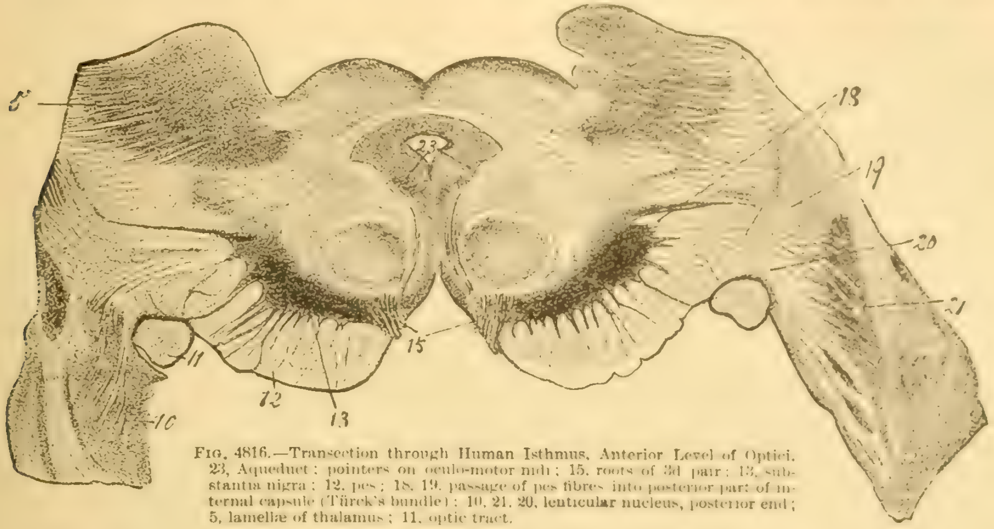

FIG. 4816.—Transection through Human Isthmus, Anterior Level of Optici. 23, Aqueduct: pointers on oculo-motor nidi; 15, roots of 3d pair; 13, substantia nigra; 12, pes; 18, 19, passage of pes fibres into posterior part of internal capsule (Türck's bundle); 10, 21, 20, lenticular nucleus, posterior end; 5, lamellæ of thalamus; 11, optic tract.

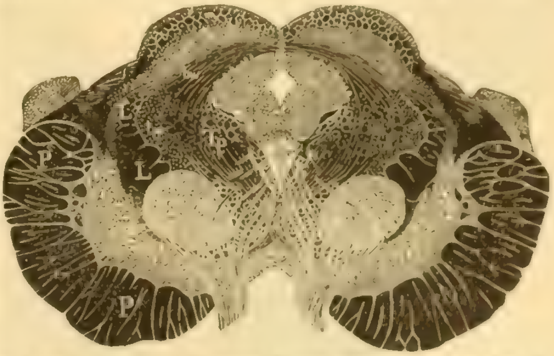

FIG. 4817.—Transection of Human Isthmus through Optici and Pes. P, Pes; L, lemniscus; T, red nucleus; Tp, fibres passing to "fountain decussations"; bw, deep white of optici.

The *nucleus tegmenti* or *red nucleus*, so termed from its reddish tinge in the fresh brain, which it owes to its richness in neuroglia as well as to its great vascularity, is found in those section levels where the ganglion of Soemmering has its greatest extent (Fig. 4817, T). In transections its outline is irregularly round, in sagittal sections an elongated oval. The nerve elements are an-polar, with numerous poles; many of the processes show a noticeable tendency to apply themselves to the walls of neighboring capillaries. The ganglion is surrounded by a capsule of medullated fibres, partly belonging to the reticular field, partly to the [illegible] [illegible]. The fibres of the latter traverse it in coarse bundles running latero-cephalo-dorsad, thus imperfectly walling the nucleus from neighboring fields.

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* Adult anthropoids [illegible]

The body of Luys is a fusiform ganglion, of a dark and yellow color in the fresh brain, which forms the cephalic continuation of the lateral part of the ganglion of Soemmering. On transection it appears lenticular, whose greater convexity is dorsad; its greatest width is just caudad of the level of the corpora mammillaria (10–12 mm. in the former, 3–5 in the dorsal, and 3–4 in the cephalo-caudal direction). It represents the boundary between the pre- and tegmentum, just as the ganglion of Soemmering does in mesencephal levels. It is made up of fine medullated fibres, crossed in great profusion and confusion with numerous delicate-walled blood-vessels, and sparse multipolar nerve elements of moderate size, angular or spindle-shaped, without any demonstrable axis-cylinder processes; while the protoplasmic processes show a remarkable resistance to staining reagents.

The tissues interpolated between the ventral face of the thalamus, the body of Luys, and the red nucleus consist of a fine, felt-like mass of fibres, whose relations are so obscure that even their boundary is not well determined (zona incerta). In the aggregate this area is known as the regio subthalamica.

The corpora quadrigemina comprise two pairs of ganglia, which are very distinct in structure. The anterior pair presents a true cortical type, which is beautifully evident in the optic lobes of lower reptiles (Fig. 818) and birds. In man the outermost layer is an expansion of the optic tract; then follows a superficial gray layer with numerous small cells,* a deep white layer, also derived from the optic tract, and deepest of all a second gray layer, containing few but large multipolar elements. The underlying tissues do not appertain to the ganglion of the anterior pair, but are a part of the central tubular gray matter and the [illegible] tracts.*

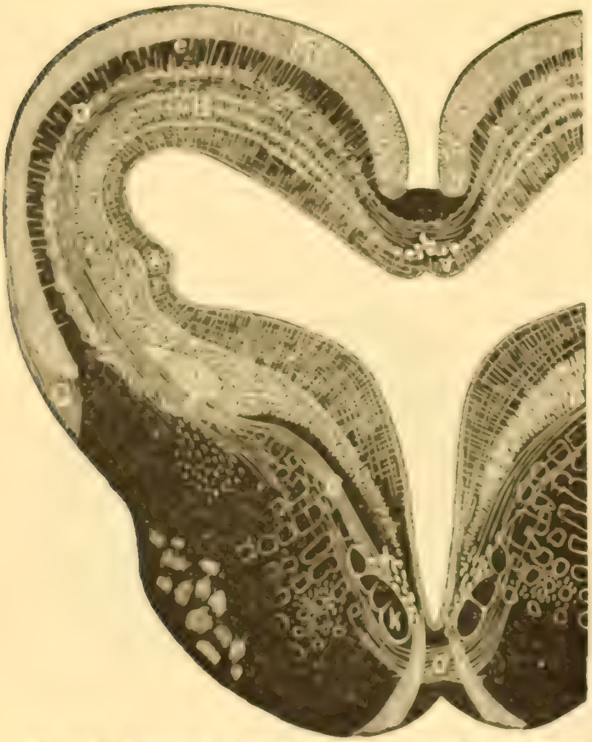

FIG. 818.—Transection of Optic Lobe of Turtle. [illegible]

The posterior pair (posterior pair) are more homogeneous in texture: a fine fibrillar groundwork, with numerous small multipolar elements. The cylindrical ganglia represented by this pair are distinct, and held in a loop of fibres (stratum zonale†), partly derived from the laqueus, partly from the post-brachium. In the median line there is an interchange of such fibres whose exact relations, whether commissural or decussational, are unknown. A similar uncertainty exists with regard to the transverse nerve fibres of which the valvula Vieussenii is composed, and which constitute a caudal continuity with the former.

The cerebellum is convoluted on a plan entirely different from that of the cerebrum. Each primary fold is folded by secondary, and these in turn by tertiary folds, so that on a sagittal section a cypress-leaf appearance is noted (Fig. 1808, "arbor vitæ cerebelli"). The white substance follows all these branchings and subbranchings, forming a core of the minute leafs which are termed folia. The gray substance presents two marked layers: an outer of a pale gray color—the molecular—an inner of a rusty brown tint—the granular layer. At the contact line of the latter with the white substance a slight intrusion of granules is noted. The closely crowded granules of the layer named after them (0.007) are of two kinds: the one studded by numerous fine fibrils, the [illegible] cells of Denissenko, are neuroglia cells; the others, with from two to four-branched processes (brush cells), are decidedly of a nervous character. At the junction with the molecular layer the neuroglia cells are flat, and form a sort of internal limiting membrane, from which radial supporting fibres run through the molecular layer connecting with the external limiting membrane, which is a delicate connective investment interposed between the true pia and the cortical layer of the cerebellar folia. At the boundary of the two cerebellar layers, but more within the molecular than the granular, are found the characteristic nervous elements of the cerebellum—the flask-shaped elements of Purkinje. These are composed of a round body elongated distad like a flask (0.065 long, 0.03 wide, 0.025 thick), with a large distinct nucleus (0.016) and nucleolus. They contain little or no pigment. Their peculiar features are the processes. The central process penetrates the granular layer. Its nature is disputed; some claim it to be the axis-cylinder process, others assert it to be lost in the net-work of fibrils in the granular layer. The distal process branches dichotomously, each cell covering an enormous field of the molecular layer with its ramifications. The branching, remarkably enough, occurs in one plane, so that only such sections as run vertical to the ridge of the cerebellar folium expose them. They are also in definite relation with the cortical superficies, so that the cells are more numerous at the apices of the folia than at the bases of the sulci. At the outer part of the molecular layer the processes become lost to observation; some claim that they become reflected and run back to the granular layer to contribute to its net-work; others assert that they spread out parallel to the surface to form a subpial plexus.

The medullated fibres of the white core of each folium penetrate the granular layer, lose their myelin, and a fine nervous net-work appears to proceed from them, with which are mingled the fibrillar processes of the nerve cells of the molecular layers.

In the interior white of the cerebellum are contained several gray masses. The largest and best studied are the dentated nuclei of each hemisphere. They are also known as ciliary bodies. Like the similarly constructed dentated nuclei of the olive, they are not dentated in lower animals—even in monkeys they are comparatively simple (Fig. 4808, 24). In man each *nucleus dentatus* is located in the mesal part of the corresponding cerebellar hemisphere, in the direct prolongation of the prepedunculus which enters it, and very close to the roof of the fourth ventricle. It is composed of a folded lamina of gray matter, convoluted like the similar nucleus of the olive, and open cephalo-mesad, where its *hilum* admits fibres from various sources, chiefly from the prepedunculus. It measures 20–22 mm. in the sagittal, 10–12 mm. in the lateral, and 11–13 mm. in the dorso-ventral direction. Its basis substance is a fine neuroglia containing numerous multipolar nerve elements (25–35 μ), which in the adult contain a yellowish pigment. The intervening substance is traversed by numerous nerve fibrils, but not as direct in course as those of the olive in the oblongata. Within the inferior vermis cerebelli there is a flat expanse of gray matter on each side, directly over the roof of the fourth ventricle, the *nucleus fastigii*. The nuclei of opposite sides approach each other so nearly as almost to fuse. The nucleus dentatus and nucleus fastigii lie nearly in a horizontal plane,* leaving an interval between them of about 15 mm. In this interval several lesser gray masses are seen. The one nearest the nucleus dentatus is elongated cephalo-caudad, the *nucleus emboliformis*;† that nearest the nucleus fastigii is exposed on section in several smaller round or oval masses, all in reality connected and constituting the *nucleus globosus*. The former is to be regarded as an accessory detachment of the nucleus dentatus, with which it corresponds in structure; the latter bears a similar relation to the nucleus fastigii, and like it has larger multipolar cells (60 μ) than the other nuclei named. The space between the cerebellar cortex and the ganglia named is filled out by the white centre of the cerebellum, which incorporates subcortical, radiating, commissural fibres and fibres emerging in the peduncles. There is every analogy between the fibre tracts of the cerebellar interior and those of the cerebrum. Thus there is a transverse commissure uniting the cerebellar hemispheres, sagittal fibres passing from end to end of the vermis, arched fibræ propriæ uniting the various folia and the hemispheres with the vermis, fibres uniting the cortex with the interior ganglia, fibres uniting the cortex with the peduncles, and finally, such uniting the dentated and other nuclei with the peduncles and auditory nerves.

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* [illegible]

* This deepest portion is commonly termed [illegible] as the "stratum [illegible]."

† The term stratum zonale is applied to all enveloping fibres, where they form a continuous layer on the outer face of any ganglion.

The part of the brain which, situated axially, serves to unite the forebrain, the cerebellum, and spinal cord, aptly termed *isthmus* by the older writers, includes the best studied as well as the most intricate constituents of the central nervous mechanism. Roughly speaking, it comprises the following: (1) The central tubular gray matter with the included cell nests from which the cranial nerves from the third to the twelfth pairs inclusive originate. (2) Nerve tracts uniting these cell nests in presumable automatic co-ordination. (3) The great nerve tracts which connect (*a*) the spinal gray with the cerebral hemispheres, (*b*) the spinal gray with the thalamus, (*c*) the spinal gray with the cerebellum, (*d*) the spinal gray with special ganglia of the oblongata, (*e*) the ganglia of the oblongata with the cerebral hemispheres, (*f*) the cell nests from which the cranial nerves originate with the cerebral hemispheres, (*g*) the cerebellum with the cerebrum. (4) The special ganglia of the oblongata and pons.

The *central tubular gray* is so termed because it retains more perfectly than any other part of the gray matter the primitive relations to the medullary canal of the embryo (see Embryology). In many places a direct transition from the epithelia of the central canal to nerve cells can be seen, and in certain lower vertebrates this is particularly distinct (Fig. 4819). The endyma, or lining epithelium of the ventricles, is composed of a finely reticulated basis substance, continuous with the substantia gelatinosa centralis of the cord. On its surface it is faced by cylindrical epithelia, ciliated at their free ends and rooted in the underlying supporting substance by fine radial fibres. Where the endymal expanse is reflected to cover the various choroid plexuses the epithelium becomes more pavement-like.

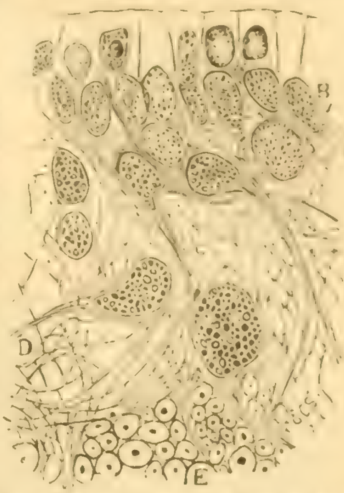

Fig. 4819.—Section near Floor of Fourth Ventricle of Menobranchus. At E transversely divided nerve tubes, at D net-work of nerve fibrils, at B transition from intermediate to epithelia and large nuclear nerve element centres.

Aside from the defined nests of nerve elements, which from their relations to the cranial nerve roots are known as the cranial nerve nidi, the central tubular gray includes scattered multipolar elements of various dimensions, and presenting every transition between the typical nerve element and the neuroglia corpuscle.

Although other ganglia are embryologically derived from the central tubular gray, and retain, even in adult man, structural connections with it, the term is conventionally limited to the gray matter surrounding the central canal of the cord and oblongata, the cornua directly connected with it, the gray matter at the floor of the fourth ventricle, the included and insulated cranial nerve nidi, and the gray matter of the aqueduct, that lining the third ventricle, inclusive of the lamina terminalis. There is a perfect continuity between the spinal gray and that of the oblongata. As far as the oblongata remains closed, the disposition of the cornua resembles that of the cord. The anterior horn, the posterior horn, with its gelatinous head, and the processi reticulares are easily recognized. The changes which gradually take place as the open part of the oblongata, where the central canal opens out into the fourth ventricle, is approached are best exposed by contrasting a transection of the upper cervical cord with one made through the closed or caudal part of the oblongata. We find the following differences:

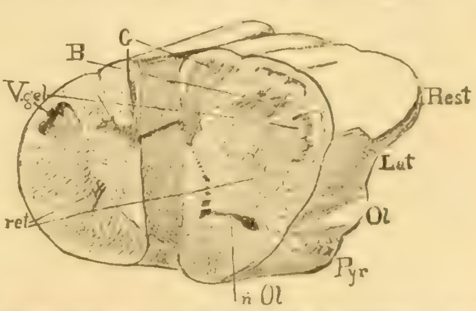

Fig. 4820.—Human Oblongata, Caudal Face to Spectator. The right half is cut more cephalad than the left to enforce the contrast. C, the nuclei of the columns of Goll; B, those of Burdach. V gel, tubes of ascending root of fifth pair; ret, reticular field; n.Ol, beginning of olivary nucleus; Pyr, pyramid; Ol, olive; Lat, lateral field; Rest, restiform column.

The contour of the cord is roundish, that of the oblongata is marked by prominences. This is due to the individualization of certain nerve tracts which emancipate themselves from the homogeneous fusion in which the spinal columns appear. They form plastic columnar protrusions on the outer face of the oblongata. Such are the pyramid and restiform columns. Other features are due to the initiation of the oblongata nuclei by ganglionic masses shown in the cord; such are the nuclei of the columns of Goll and of Burdach, and of the olive. Beginning at the ventral fissure and passing to the dorsal we encounter the following: (a) The decussation (ventral fissure); (b) the convex contour of the pyramid; (c) the sulcus between the pyramid and olive, in which the hypoglossal nerve roots emerge; (d) the bold protrusion of the olive; (e) the depressed lateral field; (f) the funiculus of Rolando; (g) the restiform column; (h) the column of Burdach; (i) the column of Goll; (j) the dorsal fissure which takes the place of the postero-[illegible] in the cord.

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* With reference to the cerebellum; in reality this plane is inclined, *i.e.*, cephalo-ventrad, downward and forward.

† The accessory part of the nucleus dentatus of Meynert.

As we pass from the level of the decussation of the pyramids cephalad, these demarcations become more distinct (Fig. 4820), and the following transitory conditions can be readily followed in the sections. The nucleus of the column of Goll (Fig. 4820, G) becomes more voluminous, inflating the slender column (funiculus gracilis) of the cord into the clava of the oblongata; the column of Burdach (B, same figure) also increases, and an accessory nucleus is seen in the periphery of the column; the caudal [illegible] of the posterior horn becomes larger and consolidated as the nidus of the ascending root of the trigeminus nerve (V asc.); the reticular field increases, particularly in its gray mesh-work, and in place of the dwindling and disappearing anterior horn, [illegible] and complicated by the crossed bundle of the pyramid tract, the internal accessory division of the olivary nucleus is seen (O). As we pass farther cephalad this latter becomes more and more prominent, inflating a special [illegible] which forces out between the pyramid and the lateral field like a bean out of its pod, the olive (O). At the same time there is a gradual shifting of fibres from the lateral field to a more dorsal position. These are the fibres from the direct cerebellar tract (myelo-cerebellar tract), joined by other fibres from deeper parts of the oblongata; they attain conspicuous prominence as the restiform column (Fig. 4820, Rest.; Fig. 4820, R). Thus the individualized tracts and protrusions growing out of local hypertrophies of gray matter give to the outline of the upper part of the oblongata a sort of butterfly-shape (Fig. 4821), owing to the deep sculpturing of its surface.

The floor of the fourth ventricle, when exposed by the removal of the cerebellum and the [illegible] membranous velum covering its posterior division, is shaped like a lozenge. The anterior end is prolonged into the aqueduct, the posterior into the central canal. It exhibits regional elevations, depressions, and color differences which are in relation with the deep anatomy of the oblongata and tegmentum. Its floor is divided into symmetrical lateral halves by a shallow sulcus ventriculi, which dips cephalad into the aqueduct, caudad into the central canal. Each lateral half is subdivided into an anterior larger and posterior smaller triangle by white striae connected with the acoustic tract. These striae are composed of medullated nerve fibres and at the sulcus appear to sink into its depth. Occasional aberrant striae [illegible] the surface of the anterior triangle. At their lateral end the surface appearance would lead the observer to regard the striae as continuous with the cochlear division of the acoustic nerve, from which they are imperfectly separated by a thin grayish ridge, the [illegible] (which corresponds to the tuberculum acusticum of lower mammals).

In the posterior triangle the middle area is occupied by an elongated triangular field, whose apex is directed to the striae, and which is of a pronounced grayish color, the ala cinerea. As its base reaches the point where the sulcus ventriculi sinks into the central canal it follows that a triangle of inverted position—that is, with its point directed caudad—is included between the sulcus, the ala cinerea, and the [illegible] end of the striae. This is the ala alba medialis. The field to the outside of the ala cinerea is the ala alba lateralis. There are thus two white triangular alae with their apices directed caudad, separated by one gray triangle with its apex directed cephalad. The gray triangle covers the nidi of origin of the vagus and glossopharyngeal nerves. The inner white triangle less accurately corresponds to the nidus of the hypoglossal. In its most cephalic part—in the angle open latero-caudad, formed by the striae and sulcus—it often shows a slight elevation, marking the site of a nidus of unknown significance.

The anterior triangular quarter-field is marked by a depression located slightly cephalad of the middle of its lateral side, which is often seen to be of a bluish color, due to a subependymal vein. A slight groove runs caudad from this fovea and but for the intervention of the striae would reach the depression containing the apex of the ala cinerea. Cephalad of the fovea, and continuing some distance along the aqueduct, is the dark bluish locus cœruleus, which owes its color to the refraction of the pigmented cells of the substantia ferruginea by the milky-white ependyma. In the angle formed by the stria and sulcus ventriculi open cephalo-laterad, is the eminentia facialis, so called because the knee of the facial nerve root, in rising to the ventricular floor, is compelled to circle dorsad and mesad of the abducens nidus at this point.

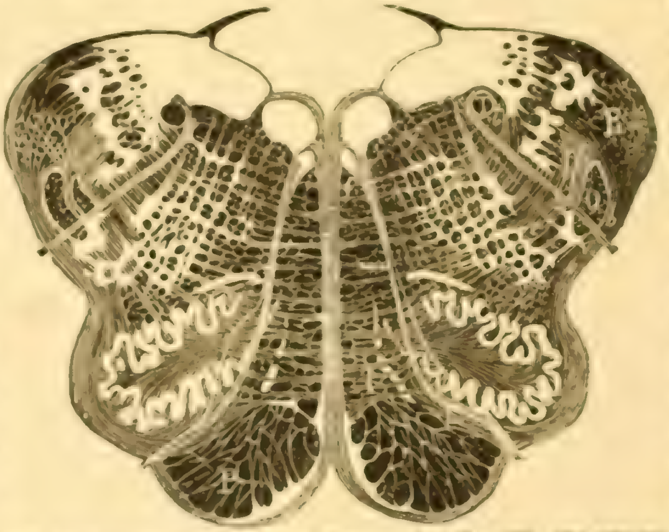

Fig. 4821.—Anterior Part of Segment Represented in Fig. 4820. The gray substance [illegible] by [illegible]. P, pyramid; O, olivary nucleus; R, restiform [illegible]; Q, ascending root of fifth pair; L, L, [illegible].

In a crude way, then, the ventricular features enumerated correspond to the deep structures of the oblongata and tegmentum, the floor of the fourth ventricle representing a rhomboidal landscape of the cranial nerve nidus field in a figure formed by the anterior and posterior cerebellar peduncles:

Ala cinerea.	Nuc. of vagus and glossopharyngeal nerves.
Ala alba medialis. [illegible]	Hypoglossal nerve. [illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Intermediate to the ala cinerea (in lower animals overlapping on it) and the clava which form the lateral boundary of the ala alba lateralis, there is a peculiar half-nervous, half lymph-absorbing organ, which is richly vascular, containing abundant fibrillar connective tissue. Its nerve cells, whose connections are as yet unknown, are of the granular variety. Aside from this tissue, the floor of the fourth ventricle is lined by endyma. The epithelia of the latter are cylindrical over the alæ, near the aqueduct, and in the sulcus centralis, elsewhere they are flatter, and devoid of cilia. Their basilar processes are connected with the neurogliar net-work.

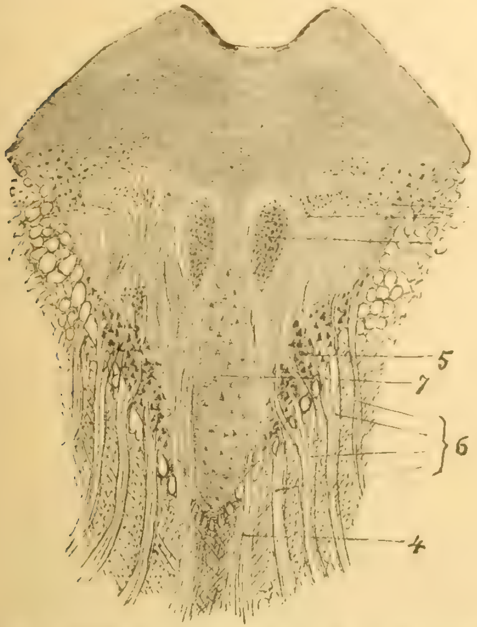

Fig. 4822.—Transection through Central Tubular Gray, Ventrad of Aqueduct in Cephalic Level of Optici (Man). 3, Cephalic nidus, vertical branch; 1, disappearing horizontal branch; 2, root fibres of third looped around the former (pupillary fibres?); 5, main ventral nidus; 7, sagittal (internal rectus?) nidus; 4, 6, roots of third pair traversing the beginning posterior longitudinal fasciculus.

The Cranial Nerve Nidi.—The origins of the cranial nerves, from the third to the twelfth, and excluding the eighth, show a great analogy to those of the spinal nerves. This resemblance extends to the shape and character of their cell-like elements. Thus those of a purely motor function (third, fourth, sixth, seventh, eleventh, twelfth, and the nidus of the motor root of the fifth) contain well-marked multipolar elements, identical in every respect with those found in the anterior or so-called motor horn of the spinal gray, so that in a structural as well as in morphological respects the analogy between the motor cranial nerves and the motor roots of the spinal nerves is a complete one. Distinct axis-cylinder processes can be traced from these cells into the respective roots. As a general rule it may be stated that the larger the muscular mass to which a given nerve is in relation, the larger is its nidus, and the larger also are the included multipolar elements. Thus those of the motor root of the trigeminus and of the facial nerve are larger than those of the hypoglossal, and this in turn is larger than the nidi of the nerves suppying the muscles of the eyeball. At the same time those cell nests related to muscles with intricate functions and subtile co-ordinations appear to have more numerous processes and a more slender and graceful outline than those of coarser function. The elements of the motor trigeminus nidus are more plump in contour than those of the hypoglossal.

The nidi of sensory cranial nerves are in like manner repetitions in structure of the posterior horn of the spinal gray. The caput gelatinosum of the cord is uninterruptedly continuous with the nidus of the ascending division of the sensory root of the trigeminus.

The substantia gelatinosa, which composes the nidi of origin of the ascending as well as the pontile portion of the sensory root of the trigeminus, presents itself as a deeply stained, apparently homogeneous blastema, containing numerous closely crowded nuclei in carminized sections. Closer observation shows that each of these nuclei has its proper protoplasm, and that the apparent continuity of the blastema is a false appearance due to the close crowding. There is a fine fibrillar net-work and a narrow-meshed glia, with numerous equally closely crowded glia cells.

In addition to these two distinct and well studied types, there is a third, of unknown functional relations. It is surmised to be associated with vegetative life, glandular or vasomotor action. The elements of this type are round, oval, or fusiform, they have one or no axis-cylinder process, and very slender, often undemonstrable protoplasmic processes. In some locations, as in the substantia ferruginea and the vagus nucleus, they become strongly pigmented with age. The fusiform ones approach the elements of the columns of Clarke in outline, those of the aqueduct nidus of the trigeminus resemble the elements of the spinal (intervertebral) ganglia, and this resemblance extends to the presence around the elements of a capsule of connective and endothelial character. There is this one textural difference between the basis substance of the cranial and of the spinal nerve nidi. That of the spinal gray is more elaborate, and differentiated into a ground net-work and cell net-work, while the former is composed of the former only, its elements supplemented by formless ground substance ensheathing the nerve elements proper.

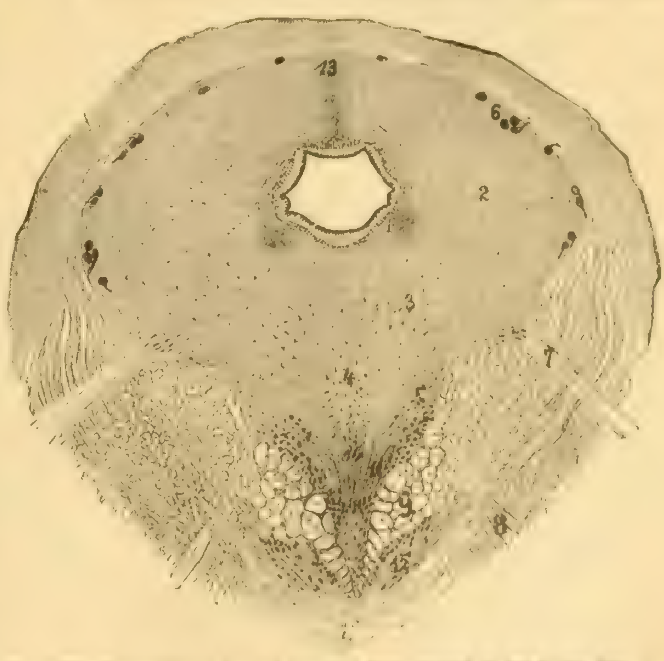

Fig. 4823.—Transection of Human Aqueduct Gray, Caudad of that of Fig. 4822. 1, Molecular masses in raphe; 2, diffuse central tubular gray; 3, [illegible] elements of same; 4, sagittal nidus; 10, fibres entering same; 6, [illegible] vesicular cells of mesencephalic trigeminus origin; 7, [illegible] rootlet probably destined for levator palpebræ; 8, rootlets from main nidus; 9, posterior longitudinal fasciculus; 12, decussatio fontanalis.

The Nidus of the Third Pair is situated in the central tubular gray of the aqueduct, at its ventral portion, and extends for the whole cephalo-caudal extent of the optici, encroaches on the level of the post-optici, and cephalad on the third ventricle, where it gradually becomes lost at the slope formed by the opening out of the aqueduct. Its nerve elements are found arranged in definite groups (Figs. 4823-4834). The most cephalic of these is composed of smaller elements, closely crowded, embedded in deeply staining molecular ground-tissue. In the level of the post-corpusculum the main nidus of each side resembles an inverted L, the vertical branch of which is close and parallel to the median line ⅂ Γ. In the cephalic part of the optici level the upper lateral extension becomes lost (Fig. 4825, 1 and 2). In this level the main nidus is composed of larger elements lying closely crowded against the ventro-lateral contour of the aqueduct gray (Fig. 4825, 5). Several small subgroups can be distinguished in it; one in the middle line may be designated the cephalic nucleus, demonstrable only by the atrophy method (Fig. 4834), as the caudo-lateral group. The rootlets of the third pair can be traced into all these groups except the last. They originate in and among them, either passing directly, or, after sweeping around them (Figs. 4822, 3, 5) and breaking through the posterior

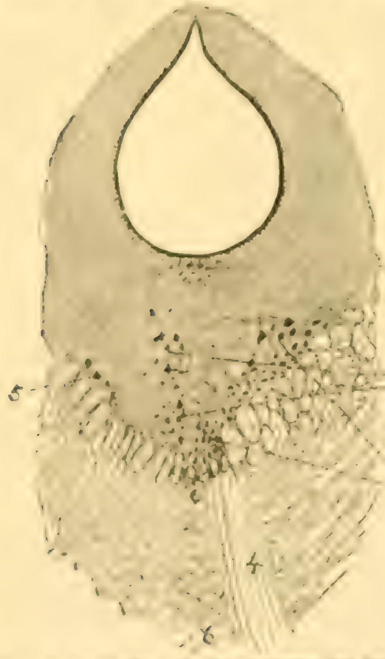

Fig. 4824.—Aqueduct Gray of a Cat, showing the Emergence of the [illegible] Third [illegible]. 1, [illegible]; 2, [illegible]; 3, [illegible]; 4, [illegible]; 5, [illegible]; 6, [illegible].

longitudinal fasciculus, separate like the strands of a horse's tail, by the interference of the red nucleus of the tegmentum, to become bunched together again in and between the mesal end of the ganglion of Soemmering and (interpeduncular region), to emerge compactly on the mesal aspect of the pes (Fig. 4817). It is demonstrated by the atrophy method as well as by direct observation, that in animals with conjugated lateral eye movements, such as man, the dog, and cat, the origin of each third nerve is not limited to the side of its exit. A part is decussated, and the decussated origin is related to the innervation of the internal rectus. Physiological and pathological considerations render it probable that the cephalic small-celled L-shaped nidus is related to pupillary motion. With regard to the caudo-lateral group, which is not connected with the third pair, it is assumed that emerging fibres join the posterior longitudinal fasciculus, to course along the floor of the fourth ventricle, eventually leaving it (Fig. 4825) between Plf and 7 g, to join the root of the seventh pair. In this way the paralysis of the facial nerve supplying muscles under the (orbicularis palpebrarum), instead of the third pair, is explained. The nerve fibres supplying that muscle are derived from the oculo-motor nidus, they only reach that muscle by another path.

The Nidus of the Fourth Pair is situated in the level of the cephalic half* of the post-optici. Its elements are larger, sharply angular, so as to appear star-shaped in many cases. The root fibres have a peculiar course; they accumulate in the latero-dorsal angle of the aqueduct gray (Fig. 4826, IVr), run caudad, gradually rising dorsad, and suddenly turn mesad to undergo a complete decussation with the root of the opposite side in the valvula (Fig. 4826, IVx). The root consequently traverses successively the molecular gray of the aqueduct, the cephalic part of the substantia ferruginea, and the valvula.

The Root of the Fifth Pair.—This enormous nerve has a corresponding extensive origin, including nuclei of the mesencephalon, pons, oblongata, and cord. They are most conveniently considered in topographical order.

A. Nidi and Roots Cephalad of the Exit Level of the Nerve.—The dorsal contour of the aqueduct gray in the

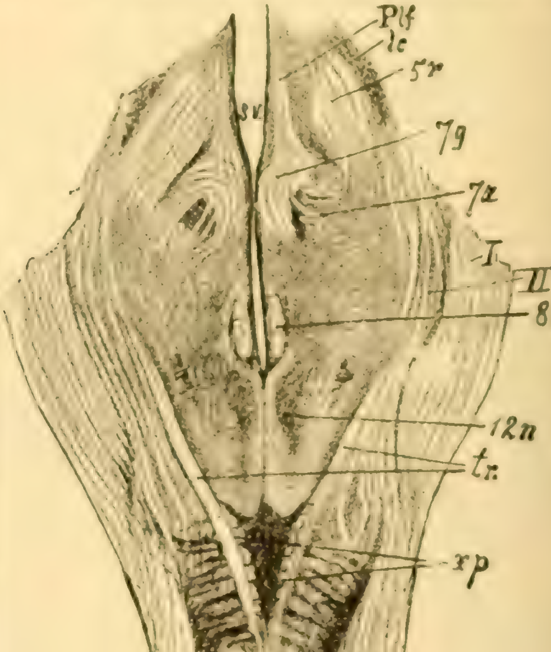

Fig. 4825.—[illegible] Section nearly Parallel to Floor of Fourth Ventricle. Plf, Posterior fasciculus of tegmentum; Sv, [illegible]; [illegible]

level of both optici and post-optici is found on transection (Figs. 4816, 4817, and 4823). Along this entire contour large elements (60 μ), spheroid or ovoid in shape, either single or in groups of two to five, are found. They are surrounded by a capsule (with nuclei), resembling the elements of the Gasserian ganglion in this and other respects. Their powerful axis-cylinder processes, soon become myelinic, and running caudad, accumulate in distinct fasciculi at the lateral angle of the aqueduct gray, where they constitute a sort of lateral appendix and extension to the posterior fasciculus. This is the descending ramus of the trigeminus roots.* The cells above described extend to the level of the velum, where they become intermingled with the elements of the *substantia ferruginea.* This latter has been regarded by some (Meynert) as a nidus of the descending root. A clear connection cannot be demonstrated, and is questioned by other writers (Forel). The elements of the substantia ferruginea are pigmented in adult man alone. While many gradations in shape between the vesicular elements of the descending trigeminus root and the former are visible, the majority are more fusiform, and lack the powerful axis-cylinder process so characteristic of the latter. They occupy the lateral angle of the central tubular gray in, and caudad of the level of, the velum (Fig. 4826, Loc.) and correspond in extent to the locus cœruleus which indicates their location in the fresh brain. The elements are 60–70 μ long and 25–35 μ wide.

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* It is said by [illegible]

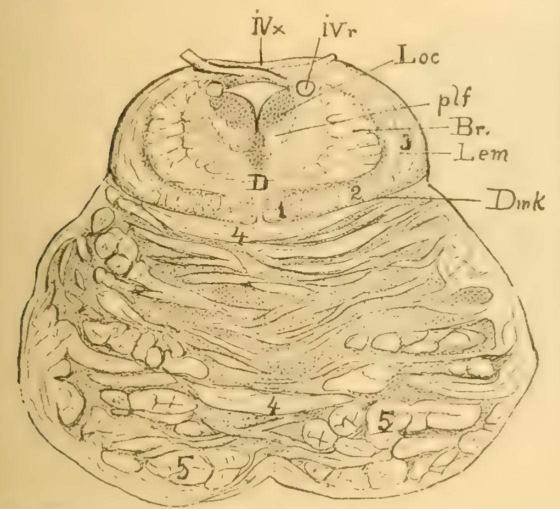

FIG. 4826.—Transection of Human Pons in Level of Valvula. IVx, Decussation of fourth pair; IVr, root of same; Loc, substantia ferruginea; plf, posterior fasciculus of tegmentum; Br, prepedunculus (*Bindearm* of Germans); Lem, lemniscus layer; 1, pedo-tegmental division; 2, main division (cortex lemniscus); 3, lateral (auditory) division passing to post-optici; Dmk, demarcation line between tegmentum and pons proper; 4, transverse; 5, sagittal fibres of pons; D, Wernekink's commissure (decussation of prepeduncle).

The Raphe Root of the Trigeminus.—In all levels of the pons ventrad of the level of the velum to the exit-level of the formed root, fibres are seen sweeping transversely from the raphe to the sensory root of the nerve (Fig. 4789, 2). A section parallel to the ventricular floor shows the real direction of these fibres from the raphe to be latero-caudad. Thin in cross-section, they occupy an enormous extent flatwise (Fig. 4825, 5r).

Nidi and Roots of the Trigeminus Caudad of the Exit-Level.—The caput gelatinosum of the posterior horn of the spinal cord in the level of the two (perhaps three) upper cervical pairs exhibits on its ectal face an accumulation of nerve fibres, which increase cephalad, until in the oblongata they constitute a distinct bundle, crescentic in cross-section (Fig. 4821, Q) which continues its cephalic course through the oblongata and pons, accompanied by more or less regularly disposed gelatinous nerve substance on its mesal border. In the caudal half of the pons it undergoes a sudden inflection ventrad, and joins the great or sensory root of the trigeminus. The gelatinous substance, whose accumulation in the caudal half of the oblongata causes the prominence known as the funiculus of Rolando, is to be regarded as the nidus of this root.

Nidi of the Trigeminus in Its Exit-Level.—In speaking of the exit-level this term must not be taken too literally. The direct roots of the fifth pair, or those of the exit-level, while rectilinear in course, emerge from the pons cephalic of their nidal origin. There are two such roots, a sensory and a motor. Their nidi are closely together in the lateral part of the tegmental division of the pons. The motor nucleus is mesad of the sensory. The former is composed of large multipolar cells, the latter of small granules closely crowded in deeply staining molecular groundwork. The latter is divided into numerous small sub-nidi, and may be regarded as an ideal though interrupted continuation of the caput gelatinosum.

The nidal relations and root origins of the trigeminus may be tabulated as follows:

Roots.	Nidal or other origin.	Destiny.
A. Descending or mesencephalic root.	A. Vesicular nidus of large vesicular elements.	A. To motor root (Forel), to sensory root (Meynert).
B. Undetermined.	B. Substantia ferruginea (?).	B. Undetermined.
C. Raphe root.	C. Decussation in raphe, probable cerebral origin of the sensory fibres.	C. To sensory root.
D. Sensory or pontin root of exit level.	D. Sensory nidus of exit level.	D. To sensory root.
E. Motor root of exit level.	E. Motor nidus.	E. To motor root.
F. Ascending or myelencephalic root.	F. Caput gelatinosum of cord and oblongata.	F. To sensory root.

The nidus of the abducens nerve is a round mass of spongy gray matter 1–2 mm. wide, containing multipolar nerve cells, somewhat larger at the ventro-lateral part than in the mesal part of the nidus (25–45 μ). It is near the floor of the fourth ventricle, in the angle formed by the acustic striæ and the ventricular sulcus, and is embedded as a stone would be in a sling in the curve made by the knee of the facial nerve root. It is this knee conjointly with the abducens nidus that causes the ventricular elevation known as the eminentia facialis. From the abducens nidus the rootlets proceed directly ventrad parallel to the raphe, spreading slightly as they traverse the trapezium, pursuing a less regular course through the pons, to emerge at its posterior border in a line continuous with the exit-line of the hypoglossal roots.

The Nidus Facialis is a single large group of multipolar nerve elements (45–60 μ) situated in the ventro-lateral part of the caudal division of the tegmental segment of the pons. It lies mesad of the auditory and emerging facial nerve roots, dorsad of the nucleus of the trapezium, and a little over four millimetres from the ventricular floor. Scattered forerunners of this nidus are found in sections at the pons-oblongata transition. The elements of this nidus are arranged in numerous sub-groups which are definitely arranged, uniformly in each individual examined by the writer. The rootlets emerge from among these sub-nuclei and converge toward the ventricular floor to there form a compact bundle. This has a remarkable course. It curves over the abducens nidus from behind (caudad), and overlies it like a horseshoe hung over a ball; not as a straight, but as a bent horseshoe, bent so that its cephalic (efferent) branch is pointed more laterad than its caudal branch, which is the one that emerged from the nidus. The curve is at the same time convex mesad. This part is known as the *genu facialis*, and together with the underlying nidus of the abducens causes an eminence on the ventricular floor previously described (eminentia facialis). After having encircled the nidus abducentis the facial root passes ventrad, and at the same time slightly ectad and caudad, passing its own nidus on its ectal face and emerges in the recessus facialis (Fig. 4827, rf. and 7). The remarkable course of this nerve root—leaving the ventrally situated nucleus to reach the ventricular floor, returning again to pass its origin on its way to the exit—is explained by the fact that at the ventricular floor it receives an accession from the posterior fasciculus.

The Nidi of the Ninth, Tenth, and Eleventh Pairs are usually considered in their topography. This mode of treating them is justified by the uncertainty which prevails regarding their peripheral innervation and complex interconnections.

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* Forel and Henle assert that it joins the motor root, all older writers that it joins the sensory root, and a few believe that it gives fibres to both.

At the ventricular floor the ala cinerea includes a gray mass which contains distinct groups of nerve elements. As the fourth ventricle merges into the central canal this gray mass extends caudad on the lateral aspect of the latter. The two groups in it are a dorso-lateral one with smaller cells embedded in a fine fibrillar network and a meso-ventral one of fusiform and roundish larger elements 35–45 μ long and 15–20 μ wide, which often become pigmented in the aged, in epileptics, and in premature * cerebral involution. Both of these groups are demonstrated to be connected with the tenth or vagus nerve. Its cardiac and visceral innervations are referred to this the subendymal nidus vagi.

More deeply embedded in the oblongata, included in its reticular field, and intermediate to the olive and emerging vagus and accessory rootlets, is a mass of multipolar elements of the same size as those of the facial nidus, which lie in the direct caudal continuation of the nidus facialis. The fibres which emerge from this cell nest take a course similar to that of the horseshoe-shaped facial nerve root. They run dorsad till they reach the solitary bundle (Fig. 4825). Then they curve around and run caudo-laterad to emerge at the lateral field of the oblongata. Those of these rootlets which emerge in more caudal levels do not penetrate the crescentic transection area of the ascending trigeminus root and become accessory nerve rootlets. Those which emerge in more cephalic levels do so encroach and constitute a part of the vagus nerve. Whichever of these nerves they join, the cell nest from which they arise merits the designation nidus laryngeus.† In addition to its origin from the oblongata, which, as physiology has shown, represents its laryngeal distribution, the accessory nerve has an origin from the cord; the cells of the spinal accessory nucleus are multipolar, large (30–40 μ), and though but few are found in each transsection, they form a long continuous column, extending from just below the middle olivary altitude to the seventh and perhaps the eighth cervical nerve origin. In the oblongata the nidus accessorii is dorso-lateral of the nidus hypoglossi. In the upper cervical level it lies in the centre of the anterior horn, and more caudad approaches and finally reaches the most lateral and dorsal part of the anterior horn. Where there is a lateral horn it is situated in it, or at its base. The roots pursue a uniform course, running to the periphery in a sharp curve, whose convexity is ventro-lateral. In the cord they closely hug the contour of the posterior horn. Near their exit they often break up into a sort of delta.

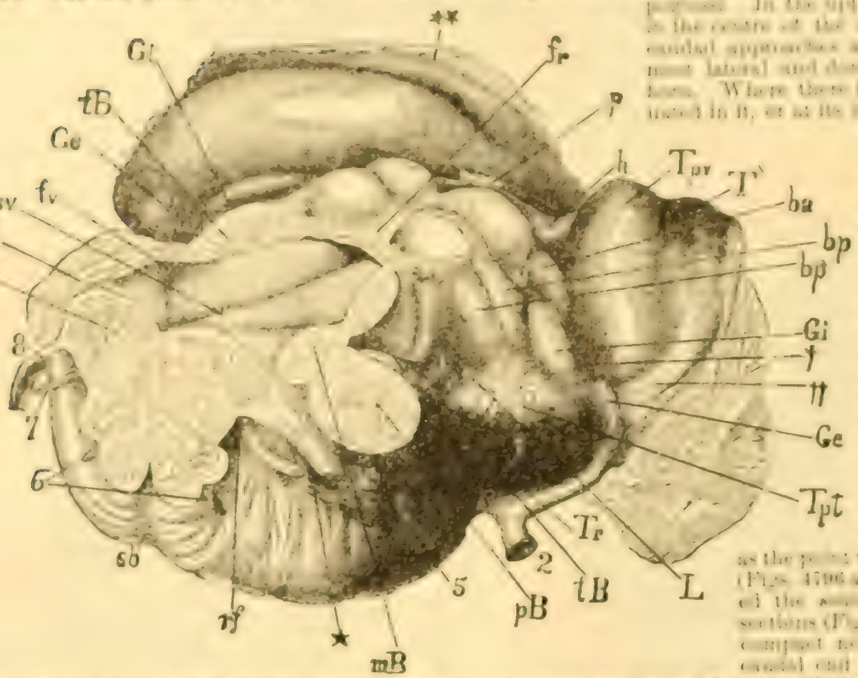

FIG. 4827.—Human Brain. [illegible] the Cerebellum Removed by a Section. [illegible] L, lemniscus; rf, [illegible]

In the levels of the oblongata cephalad of the decussation of the pyramids a round bundle is noted near the median line, skirting the central canal gray matter. This is identified in every section-level cephalad of this as far as the point where the ninth pair arise (Figs. 4796 and 4797 t), and designated the solitary bundle. In [illegible] sections (Fig. 4827, tt) it appears as a compact nerve strand, which at its caudal end approximates its fellow, suggesting a direct or decussated origin from among the fibres of the decussation of the cortex lemniscus. It is accompanied in its course by a partial sheath of gray matter. While it appears to receive accessions of fibres from the inner arciform bundles, through the intervention of this gray matter it gives off a regular series of rootlets to the vagus, and above all to the glossopharyngeal nerves. These rootlets join those which were described as derived from the nidus laryngeus in those levels where the latter is found.

The known origins of the ninth, tenth, and eleventh pairs may be summarized as follows:

The ninth pair originates directly from the solitary bundle.*

The tenth pair originates (a) from the subendymal nidus vagi in the ala cinerea (visceral nidus), (b) from the solitary bundle (sensory origin), (c) from the nidus laryngeus (motor origin).

The eleventh pair originates (a) from the nidus laryngeus of the oblongata, (b) from the nidus accessorii of the cord.

The *Nidus Hypoglossi* extends from the level of the decussation of the pyramids to very near the level of the striæ acusticæ. It bears an inverse relation to the ala lateralis, with which its outline is sometimes confounded; where the ala is widest, which is at the intersection with the striæ, the hypoglossal nidus is least demonstrable. It gradually becomes more compact caudad and with the closure of the central canal comes to lie just ventrad of the latter. In this position commissural fibres can be demonstrated to exist, uniting the two of opposite sides. In the middle of its cephalo-caudal extent it shows a beautiful grouping of cells, whose axis-cylinder processes form undulating strands segmenting it into numerous subsidiary groups, to eventually accumulate at its meso-caudal aspect, there to form the emerging root which traverses the reticular field, forming the boundary between its mesal and lateral divisions, and leaves the oblongata in the furrow between olive and pyramid (Fig. 4821). Some rootlets enter the hilum of the olivary nucleus and break through its ventral folds, others sweep gracefully between the medial accessory and main nuclei of the olive. Not all efferent fibres of the nidus take this course. A distinct bundle leaves the latero-ventral cell-groups and can be traced far ventrolaterad among the reticular meshes. At the meso-ventral edge, close to the raphe, a small nidus (Fig. 4821) is noted, whose cells are either very small, or, where larger, fusiform or spherical, and appear bipolar. Their significance is unknown. The white layer of the ala overlying the nidus contains numerous fibres, which unite the cephalic and caudal parts of the nidus with each other.

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* Insanity and senile dementia. [illegible]

† [illegible]

* It is conceivable that the glossopharyngeal nerve has a similar origin.

The description of the central apparatus of olfaction, vision, and hearing completes the enumeration of the deep origins of the cranial nerves.

The Olfactory Nerves.—The central olfactory apparatus, or olfactory lobe, comprises the olfactory tuber, tract, and bulb. The tuber is a triangular field, in front of the anterior perforated space, which is covered by a thin cortical layer. Cephalad it becomes attenuated, and continued as the tract. The tract is in section three-cornered, the dorsal corner corresponding to the edge held when in situ by the sulcus rectus of the orbital face of the frontal lobe. At its anterior end it is enlarged, and covered, as it were, by a hood of gray and white substance, the so-called bulb. (1) The bulb is covered on its free surface by an intricate plexus of white fibres, directly derived from the peripheral olfactory nerves (*fila olfactoria*). (2) The individual bundles of this layer become lost in peculiar bodies known as *glomeruli olfactorii*. These are round masses held together by connective tissue derived from the pia, partly filled by glia cells, and containing delicate nerve cells with very numerous fine, and some coarser, nerve fibres, the interstices being filled by an apparently structureless (?) basis substance. Each glomerulus is surrounded by a blood-vessel, branched like a bird's claw. (3) Inside of the glomeruli is a layer of nerve cells, resembling the smaller variety of pyramids, and embedded in gelatinous nerve tissue. (4) This is followed by a layer of granules, and (5) a medullary layer. It is from the medullary layer that the white substance of the olfactory tract is mainly derived. Here a discrimination must be made. In the embryo, as is permanently the case with many lower animals, the bulb is hollow, its cavity communicating with the anterior horn of the lateral ventricle. The axis of the olfactory bulb in man contains a slight amount of molecular gray matter, which represents the endyma of the obliterated olfactory ventricle. The white matter surrounding this (the fourth layer of our enumeration) is analogous to the white matter of the cerebral hemispheres, and connected with it by a direct superior root. It also sends a notable detachment of fibres to the anterior commissure, one division of which is a true olfactory commissure. A slender branch of this bundle leaves it before the commissure is reached, and enters the thalamus. In their course through the tract three categories of fibres may be distinguished: (1) Those which pass from the cortex of the bulb to the cortex of the tract; (2) those which pass uninterruptedly through the tract from the bulb to higher destinations; (3) those which pass in the same direction as the latter from the cortex of the tract. At its lateral and mesal edges the cortex of the tract becomes so rudimentary that the white preponderating appears as two striæ, the lateral and medial olfactory striæ. The former of these goes to the gyrus uncinatus, the latter to the cephalic end of the gyrus cinguli.

Each *optic nerve* in man contains 438,000 individual nerve fibres, which, as there are 3,360,000 cones in the retina, allows a distribution of one nerve fibre to each 6 to 8 cones, assuming an equal (?) distribution. In proportion as the binocular field of vision becomes identical, a condition most nearly approached in man, the decussation of these fibres in the chiasm becomes more incomplete. Thus, in the dog, the uncrossed bundle is one third as great as the crossed, but in man two-thirds as great. We are also able to identify the bundle of fibres which are connected with central vision. In the optic disk within the eye this area occupies a temporal sector, immediately caudad of the eyeball a marginal sickle, and behind the entry of the *arteria centralis retinæ* a vertical oval area ectad of the axis, but separate from the periphery. In the level of the optic foramen it is again peripheral, occupying a sector in the ventro lateral quadrant. The course of the optic nerve fibres toward the chiasm becomes complicated, and it is in the optic tract that we alone can identify the different strands uniting the retinæ to the visual centres. In considering these we must exclude a fortuitous ingredient, the *commissura inferior*,* a cylindrical tract which passes through both optic tracts across and in the dorsal part of the chiasm. It apparently connects the postgeniculata and has no actual relations to the optic nerves, tracts, or centres.

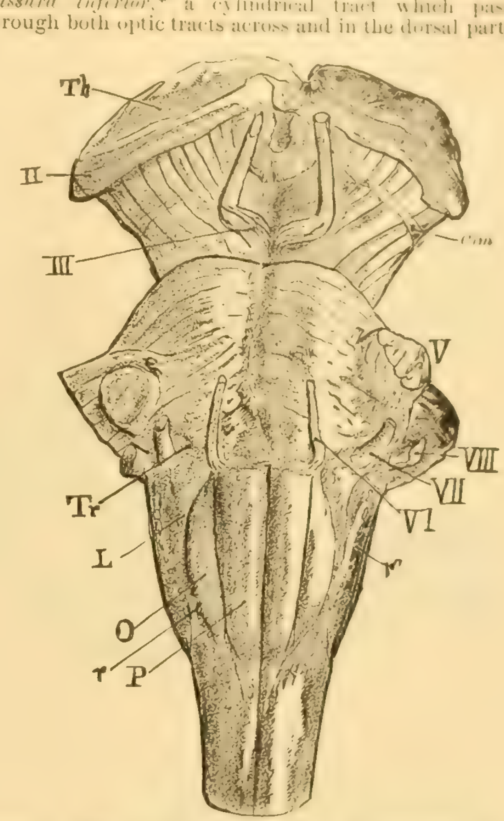

FIG. 4828.—Basal View of Sea-lion's Isthmus. II, Optic tract; III, V, VI, VII, VIII, cranial nerve roots; *Th*, cut surface of thalamus; *Cim*, cimbia (tractus peduncularis transversus of v. Gudden); *Tr*, trapezium, almost concealed; *O*, olive; *P*, pyramid.

The true optic tract passes in three divisions respectively, into the pulvinar, pregeniculata, and optici. Atrophy experiments demonstrate that from all these ganglia a powerful tract, the optic radiations of *Gratiolet*, run into the occipital cortex, distributed nearly in accordance with the distribution of the white line of Vicq d'Azyr (?). The intracoronal optic tract runs on the ectal face of the postcornu, detaching fasciculi to all the occipital gyri. In the posterior part of the internal capsule, near their entry into the pregeniculata and pulvinar, the fibres are so arranged that those representing the medial infracortical centres lie caudo-laterad, and those representing the lateral infracortical centres (pulvinar) lie meso-frontal. It is established that Gratiolet's bundle is not exclusively constructed at least in a trophic sense. When the eye is extirpated the atrophy of the optic nerve, the crossed optic tract, and contralateral optic lobe is greater than where the occipital area of the cortex is destroyed; while where the latter is destroyed the atrophy of the postgeniculate and pulvinar is greater than after enucleation of the eyeball (v. Monakow).

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* Not to be confounded with the [illegible] in the central tubular gray, one of which [illegible] of the chiasm.

The anterior members of the corpora quadrigemina (pre- and postgeminum) have been erroneously regarded as homologous ingredients of the optic system. The prægeminum is derived from the deep white matter (third layer) of the optic, and by small part from the zonal layer. These fibres pass into the deeper strata of the respective lateral of the prægeminum. They are central projecting fibres. In addition, the prægeminum incorporates fibres from the optic tract, so that it is a conduit for centripetal fibres from the retina to the optic, and from the optic to the occipital lobe. The postgeminum is connected with the post-optic and post-geniculata.

The atrophy method has demonstrated the relation to the visual apparatus of the cingulum (transverse peduncular tract), discovered by Gall and Spurzheim, rediscovered, and its real nature determined by v. Gudden. It courses round the crus from the anterior margin of the optic, to lose itself, passing the mesial fasciculi of the pes, constituting a visible prominence in some cases (Figs. 4777, 4778, and 4779). Destruction of the retina or of the occipital lobe causes atrophy in it, and the atrophy is total and crossed in animals with complete decussation of the chiasm, partial and bilateral with those having semi-decussation of the optic nerves.

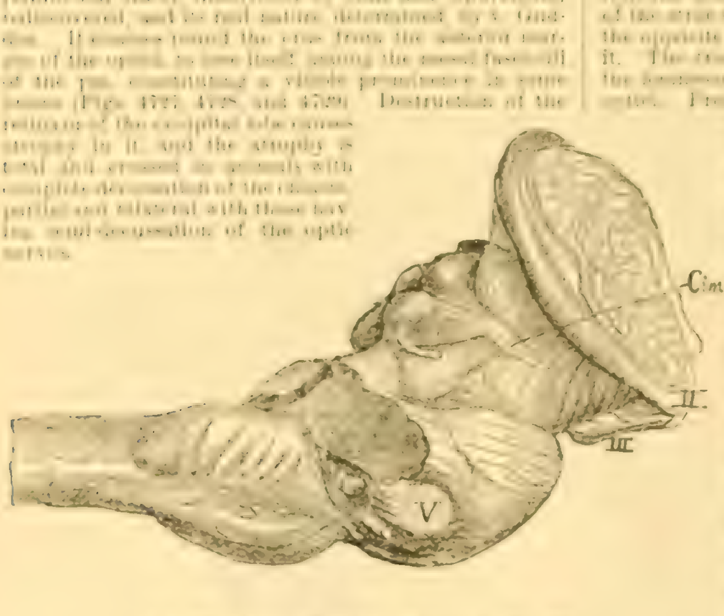

FIG. 4829.—Lateral View of same Isthmus as Fig. 4828.

The acoustic nerve is composed of two divisions, distinct at their termination in the cochlea and vestibule, and distinct at their origin from the oblongata. They differ in texture. The cochlear division has finer fibres, and the myelin sheath has no rings of Ranvier. The vestibular part has coarse fibres with thick myelin sheaths, showing the usual characters of peripheral nerves. In addition it contains small islands of gray substance. The cochlear division at its oblongata entry lies caudad and dorsad of the other. It courses round the convex face of the restiform column and enters into direct connection with a nidus of nerve elements, filling out the triangular space between the cochlear entry dorsad, the vestibular entry ventrad, and the restiform column mesad. It is also connected (probably indirectly and after interruption in the nidus mentioned) with the tuberculum acusticum. This body is represented in the human brain by a thin gray lamina, apparently interposed between the lateral part of the striæ, swelling to its largest dimensions in the lateral angle of the fourth ventricle, and becoming gradually lost in the cochlear root. In lower mammals it is much more voluminous, and shows an exquisite cortical texture, there being (1) an outer barren layer; (2) a layer of small cells; (3) a layer of large cells; (4) a deep medullary layer. Its relative atrophy in man is in harmony with the fact that all the primary centres of special sense (bulbus olfactorius, superficial strata of the optic, tuberculum acusticum) have become reduced, owing to the higher development of the secondary centres in the cerebrum and subcortical ganglia. The ganglion cochleare is regarded as the homologue of a spinal ganglion for the cochlear nerve, which has become included in the oblongata, for in some lower vertebrates it is represented by an extramedullary ganglion.

The origin of the vestibular division is disputed. That it is connected with the vermis cerebelli is the only well-ascertained fact. The fibres having this origin can be distinctly traced traversing the restiform column, or running mesad of it in the cerebellar interior. Its oblongata entry is between the ventral face of the restiform column and the latero-dorsal aspect of the ascending trigeminus root.

The auditory tract has been traced, mainly by the atrophy method, from the entry of the cochlear division of the acoustic nerve in the tuberculum acusticum and acoustic field to the convolutions of the temporal lobe. Arched fibres from the tuberculum acusticum, to the reticular field of the pons-oblongata transition, and those of the striæ of the ventricular floor cross the raphe, find the opposite nucleus of the trapezium, and connect with it. The tract thence passes into the lateral division of the lemniscus layer. This enters the ganglia of the postoptic. From the latter the arm of the postoptic lobe, almost indistinguishably fused with a tract from the internal geniculate body, passes through the posterior part of the internal capsule to the cortex of the two upper temporal gyri at their posterior portion. Notwithstanding the fact has been questioned by the followers of Flechsig, the striæ acusticæ are to be regarded as connected with the auditory nerve roots. The only well-ascertained fact as to their course is that they dip into the raphe (Fig. 4825, St) and probably decussate therein.

Several gray masses are found in the interior of the oblongata and pons without possessing any direct relation to the cranial nerves. They are, at least in the majority, intercalary stations of the great fibre systems to be considered at the close of this article.

The first addition noted on tracing the spinal gray into the oblongata is the development from the posterior gray commissural part on either side of a long pedunculated and a broad sessile gray mass. The former extends into the column of Goll, and reaches its greatest volume in the clava. The latter extends into the column of Burdach.

In the level of the striæ acusticæ a distinct accumulation of small nerve elements, closely crowded, is found on either side of the sulcus ventriculi, the *nucleus funiculi teretis*. Its relations are unknown. Similar, more attenuated, and irregular masses are found in the external arciform fibres and scattered in the raphe. The former are known as nuclei arciformes. The nerve elements of the nuclei of Burdach, Goll, and the nuclei just named are so similar that one description will serve for all. They are small, angular, multipolar elements, often showing a transition to granules (15-25 µ long, 5-10 µ wide) from which an axis-cylinder process can be traced into the numerous nerve strands which break into these nuclei and divide them up into numerous subdivisions. The distal division of Burdach's nucleus is an exception. Here the elements are nearly twice as large (30-40 µ long, and 12-18 µ wide).

The nucleus of the column of Burdach is divided into two portions by the followers of the atrophy method. The lateral division this method shows to be intimately connected with the fibres of Burdach's column, while such a relation, if at all present, is very slight in the case of the mesial division. The cephalic connections are not so determined; by exclusion, relations to the restiform column, to the olive and the nucleus of Deiters have been negatived. It is very probable that the inner division of the cerebellar peduncle, as well as some fibres of the reticular field originate in it. It is certain that a part of the cortex lemniscus is derived from arched fibres originating in the nucleus of the column of Burdach, decussating across the raphe, and running a course similar to the arched fibres from the nucleus of the column of Goll.

The nucleus of the olive (Figs. 4796, 4797, and 4821) is a corrugated lamina of gray matter, whose extent nearly corresponds to the elevation seen on the base of the oblongata. It can be compared to a hollow oval sac, slit on its mesal aspect, and the edges of that slit everted. The eversions are known as the accessory olivary nuclei, the main mass, from the appearance presented by its corrugated folds in cross-section, is termed the dentated nucleus. The opening is the hilum. Numerous fibres run into the interior through this hilum, and others cut through the lamina to join the fibre arches of the reticular field and those passing toward the restiform column. As the hilum does not extend the whole length of the olivary ovoid, section through the cephalic and caudal ends of the latter show the dentated nucleus to be closed on all sides, while those passing through the middle two-thirds reveal the hilum. The inner accessory olive is continued as a caudal spur, bent like an obtuse L (on cross-section), caudad of the caudal extremity of the dentated main nucleus (Fig. 4797).

A section through the middle of the olive exposes the different divisions of the nucleus in their clearest relations (Fig. 4821). It is seen to consist of a main mass, and of two subsidiary detachments, all having the common structure of a gelatinous lamina containing numerous evenly distributed nerve cells, whose processes are few and can but rarely be traced beyond the border of the lamina in which they are situated. The olivary nucleus is in intimate relation with the arciform fibres in every altitude, some of these, the external arciform, merely course round its ventral face, others break into its nervous lamina, or cut through the accessory nuclei, and a large number accumulate in its interior after having entered at the hilum. We shall learn to recognize in this relation the rôle which the olive plays as a station of the restiform decussation. On the interior as well as the exterior of the olivary nucleus there are also longitudinal fibres. The hypoglossal nerve root passes through the olivary nucleus without entering into any connection with its nervous substance.

The *nucleus magno-cellularis*, discovered by Deiters and often designated by his name, is situated mesad of the restiform column at the entry level of the acustic nerve roots. From this fact and the clear and distinct entry of the fibres from the latter into its gray substance it was regarded as an acustic nidus. But nothing could better illustrate the fallacy of relying on the apparent connection of nuclei and tracts than this case. For it has been conclusively shown that destruction of the acustic nerve does not affect the cells of the magnocellular nucleus at all, while hemisection of the cervical cord leads to their total atrophy. It is probably a station for a spinal tract.*

Aside from the nidi and ganglia in the isthmus large nerve tracts run through it, for whose better understanding and classification the isthmus is assumed to be composed of a dorsal part, the *tegmentum*, and a ventral part, the *pes*. The boundary between them is furnished in the thalamic level by the ganglion of Luys; in the level of the optici by the ganglion of Soemmering; in the pons by the demarcation line, and in the oblongata becomes obliterated, but may be assumed to lie between the pyramid and the interolivary layer. The overwhelming majority of nerve fibres in the pes is derived from the cerebral hemispheres or their ganglia. The overwhelming majority of the fibres of the tegmentum is derived from the thalamus, optici, post-optici, and other ganglia scattered through it. The chief of these tracts are the lemniscus, the prepedunculus, the trapezium, the posterior longitudinal fasciculus of the tegmentum, and the restiform column with its appended inner division of the cerebellar peduncle.

From the level of the optici to the spinal cord the tegmentum is more or less perfectly divided into lateral halves by the *raphe*. This important structure varies in composition in various levels, being the medium through which various interchanges of fibres takes place. Occasionally it is entirely interrupted, as at the decussation of the prepedunculus (brachium conjunctivum, so-called commissure of Wernekinck, Fig. 4826, D) and the decussation of the pyramids, where it practically ends.* In the pons the raphe is limited to the tegmental segment. Proceeding caudad the following features are found in it: I. The *decussatio fontinalis*, so called because of the resemblance of the scattering strands to the jets of a fountain. It lies in the level of the optici, and is a decussation of tegmental fibres from the thalamus or the optici (?). II. The *fibræ rectæ*. These are fibres whose direction in the main is vertical (dorso-ventral). They are found from just caudad of the valvula level to the decussation next to be mentioned. It is with these fibres that the raphe root of the trigeminus is continuous. In the oblongata the fibræ rectæ are specially well developed. Some of them are derived from the external arciform fibres, some from the internal. Often the appearance is seen as if such fibres ran uninterruptedly from the pyramids, or pyramid tract, to the cranial nerve nidi at the floor of the fourth ventricle† (Fig. 4821). But it is also found that large numbers of arciform fibres entering the raphe on one side, after a longer or shorter course in it, leave it on the other; and most authors incline to regard the raphe as a continuous decussation, whose decussation angle is so fine as to simulate parallelism. Fusiform nerve elements are found in the raphe, particularly in those levels corresponding to the cranial nerve nidi, independently of those accumulations which have been considered in conjunction with the nuclei arciformes.

Among the most striking features of a cross-section of the oblongata are the arched fibres (*fibræ arciformes externæ* et *internæ*). Some of them are visible as distinct strands on the exterior, coursing round the caudal end of the olive, and often masking the prominence of the pyramids. In this situation the external arched fibres incorporate one or more flat lamellæ of gray substance, structurally like the olivary gray, known as the *nuclei of the arciform strands*. The internal arciform fibres in great part enter the olivary hilum, others enter the reticular field; some cross the raphe directly, others run in the raphe for a greater or lesser distance. It is among these fibres that we occasionally find small islands of gray substance, resembling in structure the nuclei of the arciform strands. It is largely due to the accumulation of arciform fibres on the dorso-lateral part of the oblongata that the restiform column owes its size. Their ultimate origin, which is probably derived from some spinal tract through the olivary nuclei, is as yet disputed. Less doubt exists as to another ingredient of the restiform column. The *direct cerebellar tract* originates in the lower dorsal cord, is situated, in cross-section, at the periphery of the lateral column on its posterior quarter or two-fifths (for its area increases cephalad). This area is crescentic and embraces the pyramid tract ectad. In its course through the dorsal cord it receives constant accessions of fibres from the vesicular columns of Clarke. These fibres spread out brush-like in transection levels and traverse the neck of the posterior horn and the pyramid tract to reach the direct cerebellar tract. The latter continues its course cephalad, and in the caudal part of the oblongata occupies the lateral field. Here its fibres change course, running sharply dorsad, they form a belt on the ectal face of the ascending trigeminus root to pass into and merge with the restiform column. With the latter they reach the cerebellar interior, and by means of the atrophy method are traced into the cortex of the dorsal vermis cerebelli. As the vesicular columns of Clarke sensitive centripetal fibres from the posterior spinal roots, the following may be laid down as a provisional course of this tract:

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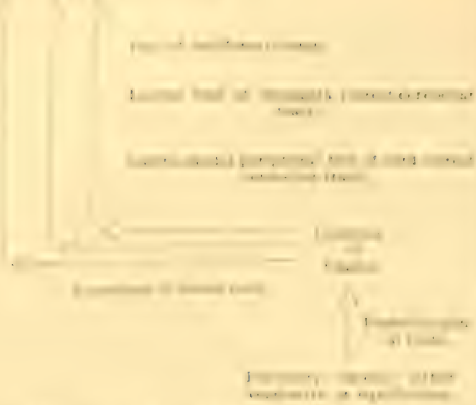
* V. Monakow states it to be connected with Burdach's column. Vejas denies this.

* To be faintly represented in the [illegible] cord.

† The connection has not been demonstrated. It is the substratum of Meynert's theory of motor projection.

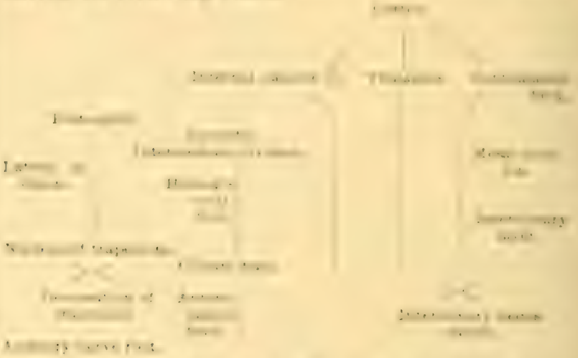
Course of [illegible]



The *inner division of the cerebellar peduncle* is an imperfectly demarcated strand on the mesal side of the restiform column (Fig. 4827, II) and topographically corresponds to the attenuated cephalic prolongation from the clava. It is connected caudad with the nucleus of the column of Burdach, and cephalad runs into the nucleus of the fastigium, partly crossed and partly uncrossed. In its course there is some gray substance, which is imperfectly continuous(?) with the accessory nucleus in the column of Burdach.

The *prepeduncle** (Fig. 4827, 1 B) originates in the hilum of the ciliary or dentated nucleus of the cerebellum, becomes a distinct surface strand of the tegmentum, and in cross-section lies mesal of the zonal fibres which connect the lateral lemniscus with the post-optici (Fig. 4826, Br). Just dorsad of this level its fibres pass to the raphe and there decussate, totally or partially (?), with those of the opposite side (Wernekink's commissure). After decussation they pass to, encapsulate, or enter the red nucleus of the tegmentum. An oblique, flatwise section would thus expose the contour of a scissors half open. The handles would be the two red nuclei, the bridge the decussation, the pointed cutting ends the prepeduncles, whose points would lie embedded in the dentated nuclei of the cerebellum. Indirectly this tract is supposed to be continued from the red nuclei to the ventral lamina of the thalamus by a special field of subthalamic fibres.

The term *lemniscus* (fillet) was originally applied to a triangular surface area on the lateral face of the mesencephalon and the fibres which, corresponding to it, could be traced deeply through the isthmus to the neighborhood of the olives. Considered as a whole, it is best studied in a transection at the level of the valvula (Fig. 4826). It here occupies an L-shaped field, the horizontal branches of those of opposite sides nearly meeting at the raphe (L, L). It is directly dorsad of the demarcation line of the pons and consequently constitutes the most ventral part of the tegmentum. Its horizontal division is confusedly spoken of as the "lemniscus stratum." The part which can be traced farthest cephalad is spoken of as the "upper," the part which connects with the stratum zonale and terminates in the ganglia of the post-optici as the "lower" division. The last designations are derivative from their topographical arrangement in transection. Nearest the raphe there is a crescentic bundle, embedded in diffuse gray matter, which is an aberrant bundle from the pes.† It should not be considered as a component of the lemniscus. Directly overlying the deep (dorsal) transverse pons fibres is the interolivary tract, so called because it is continuous with that division of the reticular field which in the oblongata lies dorsad of the pyramidal tract, and between the opposite olivary nuclei. Immediately laterad of this is Helweg's oval field* and most laterad a large field which, embodying the auditory tract, connects the trapezium with the post-optici. It is this part which includes the lateral ganglion of the lemniscus, a reticular mass of gray matter with small cells. The other bundles of the lemniscus are separated by molecular gray matter in less heavy accumulations. In a cephalad direction the lemniscus may be described as having the following course:



Its best known ingredient, the *interolivary lemniscus tract*, extends in its demonstrable course as follows: In the level of the optici (Fig. 4817, L L) it occupies a lamp-shaped area, laterad of the red nucleus, and curved over cephalad.‡ In the upper pons levels it is the mesal part of the true lemniscus layer, and, passing into the interolivary layer, decussates into the nuclei of the columns of Goll and Burdach (Figs. 4789-4797, D, DS, Da, Dam). It is through these nuclei indirectly continuous with the tract of the column of Goll and the tract which is represented in the comma-shaped area of the column of Burdach.

The *trapezium* consists of a transverse fibre mass situated in the ventral part of the tegmentum, nearly coinciding with the entry level of the cephalic acoustic root. On transection (Fig. 4800) it exhibits numerous fibres slightly wavy in their lateral, directly horizontal in their intermediate part, and separating at the raphe, where they undergo a sharp-angled decussation. In its lateral part the trapezium incorporates a folded cell mass better developed in lower animals than in man—the nucleus of the trapezium. It has been compared to the nucleus of the olive. Like it, it presents denticulations, a hilum, and accessory nuclei. Cephalad it extends into the lateral part of the lemniscus with an attenuated prolongation (Fig. 4807). The fibres of the trapezium bear a similar relation to it which certain arciform fibres bear to the olivary nucleus, that is, they enter its hilum, decapsulate and break into it. Owing to the defective development of the pons in lower mammals, the trapezium in them becomes exposed at the base of the brain (Fig. 4798), but much less so in those which approach man in the relative preponderance of the hemispheres (Fig. 4828). It is probably a part of the centripetal auditory tract.

The *posterior longitudinal fasciculus of the tegmentum* extends from the level of the optici into the deepest (most dorsal) part of the anterior column of the cord. It is everywhere, in this extensive course, closely applied against and ventrad of the central tubular gray, running beneath the oculomotor, the trochlearis, abducens, and hypoglossal nuclei. On cross-section the bundles of both sides resemble the horns of an ox (Fig. 4826, plf). They suffer a sudden reduction in the level of the abducens nucleus. Their incorporation of fibres running from the nidal centre of the orbicularis palpebrarum to the facial genu, and their probable inclusion of those fibres which unite the homolateral nidus of the external rectus of the eye with the nidal centre for the contralateral internal rectus, justifies the view that they are devoted to co-ordination of eyeball movements. They are, in accordance with this view, rudimentary in blind animals. The axis cylinders of the posterior fasciculi are of various dimensions, very large ones preponderating.

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* Superior peduncle.

† See [illegible].

* The term is [illegible] transferred to the [illegible].

‡ In Fig. 4818 [illegible]

The ingredients of the *tegmentum* thus far enumerated, while the most characteristic and easiest studied, do not exhaust the anatomy of this part of the isthmus. There is a considerable space left in the oblongata, bounded mesad by the raphe, dorsad by the nidi and dorsal nuclei, ventrad by the olivary nuclei. It extends to the lateral field, the ascending trigeminus root and restiform column. In the pons its boundaries are the same, except ventrad, where the lemniscus takes the place of the olivary nuclei, and laterad, where the series of emerging auditory and trigeminus roots takes the place of the restiform column. In the level of the optici it is bounded mesad by the ventral apex of the central tubular gray and interpeduncular ganglion, dorsad by the deep gray of the optici; laterad imperfectly by the thalamus and internal capsule, with which it partly fuses (?), and ventrad by the substantia nigra. Up to this level it is termed the *reticular field of the tegmentum*, from the basket-work pattern exhibited by its interlacing fibres. This structure is heralded in the spinal cord by the *processi reticulares*, prolongations of the spinal gray, which ramify, anastomose, and thus produce a net-work, entrapping in its meshes fasciculi of white substance. Interrupted by the decussation of the pyramids, they reappear, but much more voluminously, in the oblongata. Three sets of fibres form its lattice-work: a sagittal, composed of fibres apparently extending from the thalamus and subthalamic fields into the posterior and lateral columns of the spinal cord. These fibres are cut across in transections, and therein appear as round or quadrangular areas of axis cylinders. The other two series run in the plane of the transection, comparable to equatorial and meridional lines. One set, the fibræ arciformes, runs in a gentle circular sweep from the region of the restiform column—in lower levels from the nuclei of the columns of Burdach and of Goll—to the raphe. The other crosses them at nearly right angles, incorporating and running parallel with the emerging roots of the ninth to twelfth cranial nerves. Wherever there is a space in this lattice-work it is filled out by gray substance, in some places merely molecular, in others embodying neuroglia and small nerve elements. From the level of the trigeminus exit to the decussation of the pyramids it incorporates multipolar nerve elements, among the largest in the nervous system, as individuals or as groups. In its aggregate this scattered gray matter, which repeats the lattice-work arrangement of the white bundles as much as a negative can imitate its matrix, would constitute a bulky accumulation of gray matter, the *reticular ganglion*.

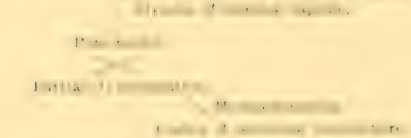
A minute study shows that the continuity of the sagittal fasciculi of the reticular field is more apparent than real. Fibres leave one bundle to join another, and may, for all we can demonstrate to the contrary, leave the latter again. Many connect with the elements of the reticular ganglion, which appears to be a depot, mediating the transition of sagittal to equatorial and meridional fibres, and *vice versa*. A number of imperfectly known nerve tracts are traced into the reticular field from the cord. The *antero-lateral spinal tract* is an as yet imperfectly studied bundle occupying a triangular area with a peripheral convex and two inner concave sides, in the anterior half of the lateral column of the cord. It may be crudely regarded as an ideal continuation ventrad of the area of the direct cerebellar tract, with which it has been confounded. Its mesal angle is prolonged toward the anterior horn. The English writers (Tooth, Sherrington, Gowers, Haddon) do not trace it far cephalad. Helweg asserts that it occupies a position in the lateral field of the oblongata ventrad of the direct cerebellar tract and ultimately merges into the halo olivaris, through which it becomes a part of the tegmentum (the oval tract of the tegmentum), which is the direct cephalic prolongation of the halo. Similarly certain nerve tracts from the diencephalon are traced into the reticular field from above. Those which become components of the lemniscus, prepedunculus, and posterior fasciculus have already been considered. In addition a distinct group of nerve bundles (*tegmental fasciculi*) can be traced in its lateral field from the thalami. The *posterior commissure*—which, according to some authors, constitutes a true commissure of the tegmentum, according to others a decussation of thalamus fibres—contributes fibres to its mesal division. Near the raphe, immediately subjacent to the posterior fasciculus, is a field of large axis cylinders derived from the *decussatio fontinalis*.

In the level of the red nucleus the tegmentum includes a remarkable bundle of fine fibres devoid of myelin, forming a homogeneous column. It passes dorso-ventrad, slightly caudad, uniting the ganglion habenulæ and ganglion interpedunculare (*Meynert's bundle, fasciculus habenulo-interpeduncularis*). Owing to the prominence of the red nucleus in man, it makes a slight curve to pass on its mesal side, and often traverses a groove in this aspect of the ganglion.

Throughout its entire extent there is an interchange of fibres across the raphe, between the opposite halves of the tegmentum. These decussations are most numerous from the level of the optici to the decussation of the prepedunculus.

The pedal part of the isthmus incorporates the pes pedunculi, pons proper, and pyramid. The composition of the former is practically identical with that of the internal capsule; exceptional features will be noted in their proper place. The term *pons* is used in a double sense; topographically the entire segment of the isthmus separated by a transection made cephalad of the anterior border of the pons elevation, and caudad of its caudal border is thus designated. On continuing these sections through its interior it is seen that everywhere there is a sharp line of demarcation between a dorsal and ventral portion (Figs. 4789, just below mark 5; 4799, just below end of mark Id; and 4826, Dmk). The dorsal division is uninterruptedly continuous cephalad with the lemniscus and thalamus, caudad with the reticular field of the oblongata, in short it is the united tegmentum. The ventral division is composed of a transverse mass of fibres, derived through the medipedunculus from the cerebellum (Figs. 4826, 4; 4789, 4; and 4799, Plo, traversed in a sagittal direction by the fibres of the pyramid (Fig. 4799) and pes pedunculi (Fig. 4826). This is the pons proper. To understand its constituents let the reader imagine a truncated cone, standing on its caudal as the smaller end, imagine further that it be split at its cephalic part, and that a belt had been welded around it to prevent that split from widening. The split and separating upper end would represent the pes of each side, the lower end the pyramids, and the belt the pons. On examining further we find that the transverse fibre mass is built up from two sources. If the section area of the pes be compared with that of the pyramids—for the two are directly continuous—it is found that only one-fifth of the former is represented in the latter. Consequently about four-fifths of those fibres which were derived from the internal capsula and concentrated in the pes become deflected from their course and lost in the pons. This they do partly by direct entry into the medipedunculus of the same side (Gratiolet, Türck, Flechsig), partially by decussating into the opposite side (directly ?) and partly by terminating in the proper ganglia of the pons. The latter are irregularly shaped gray masses, whose disposition may be best understood by conceiving the spaces left as the transverse bundles separate to permit the sagittal to traverse, filled out by gray matter. The tracts connecting the cerebral cortex and cerebral ganglia with the cerebellum all pass through the pons proper. (1) From the frontal cortex to the pons nuclei; this tract is situated in the medial part of the pes and encroaches on the periphery ventrad of the pyramid tract. (2) From the temporal cortex to those nerve elements of the pons ning in (between the pyramid and lemniscus); it is situated in the lateral third of the pes.

It is demonstrated that those fibres from the cerebral sphere which originate in the occipital, temporal and parietal regions are represented in the dorso-cephalic tegmental tract of the pons. Among these bundles the best known is that tract* which connects the occipital and temporal lobes with the cerebellum, through the pons nuclei (Flechsig) or directly (Majewski); it is situated in the lateral part of the pes and probably continues later in and parallel with Gudden's optic radiations. As regards all other connections between the cerebrum and cerebellum through the pons, the following plan may be regarded as representing their general character; the tract above mentioned serving as a paradigm.



The putamen of the lenticularis and the caudatum are connected with fibres which run in that part of the pes nearest the ganglion of Soemmering and immediately among its processes. It is as yet uncertain whether they connect with the ganglion or into the lemniscus.†

The voluntary motor tract originates in the pyramidal elements of the cortex cerebri. The bundle of fibres comprising it are an ingredient of the corona radiata and occupy in their origin, over one-third of the cortical area: the pre- and postcentral, the caudal ends of all the frontal gyri, the paracentral lobule, the superior parietal lobule, and even a few fibres from the cuneus. From a great part of this origin the fibres are scattering; the compact core of the voluntary motor tract would appear triangular in a horizontal section and corresponds in its axis to a line drawn from the junction of the paracentral lobule, the precuneus (superior parietal lobule) and the postcentral gyrus. The caudal angle extends into the precuneus, the ectal angle toward the sulcus of Rolando, the mesal (cephalic) angle to the paracentral lobule. After the fibres have become concentrated they compose a distinct ingredient of the corona (Rolandic loop) and enter the internal capsule, occupying a situation just caudad of the knee of the capsule, extending from the latter to a little caudad of the thalamo-lenticular or posterior middle division of the capsule. Pathological experience teaches that the genu part of this tract represents the voluntary innervations of the cranial nerve distribution. This part we will omit from consideration for the present. The trunk of these fibres is known as the *pyramidal tract*, from its ultimate condensation in the pyramids of the oblongata. It enters the pes pedunculi in such a way that the fibres, which in the corona were cephalic, become ventral, and caudal, lateral, in the pes. The bundles which are collected very much like the pieces of a fan at the handle. The semi-spiral twist they undergo is indicated in the fascicular sculpturing of the ventral face of the pes. In the pes it occupies one-fifth of the total area in and slightly ectal of the middle of its transsection. The pyramid tract then traverses the pons (Figs. 4789, 4790, 4791 Pyr, and 4826, 5), emerging as a compact ventral column in the oblongata; the pyramid proper. Which, arrived at the ventral fifth of the oblongata, decussates with its fellow of the opposite side, visibly to the naked eye, the alternate fasciculi interdigitating in the ventral fissure. The fibres for the arm decussate cephalad, those of the leg caudad.‡ Not all the fibres of the pyramid decussate; a minority remain in the original position on the same side of the ventral fissure. The former, or *crossed pyramidal tract*, enters the dorsal part of the opposite lateral column and extends uninterruptedly down to the lower lumbar levels of the cord. It undergoes abrupt diminutions in area, on the cervical as well as the lower dorsal (upper lumbar) levels of the cord, due to the entry of its fibres into the processus reticularis of the gray substance. Whether, as v. Monakow claims, they here contact with the multipolar small elements of the reticular processes, or traverse the latter uninterruptedly to enter the large multipolar elements of the anterior (ventral or motor) horn of the spinal gray, it is admitted that they are related to voluntary motility of the extremities. The fibres which remain on the side of the ventral fissure and remain constituents of the anterior column of the cord, constitute the *direct pyramidal tract*. They are not in immediate contact with the white commissure of the cord, but send fibres into it, so that they probably decussate through this commissure in their entire extent, which reaches to the upper third of the dorsal cord, repeating in detail what the crossed tract does in bulk.

Anatomical variations are said to exist in the course of the pyramid tract. v. Monakow found its crossed portion to be exceptionally [illegible] of the [illegible]. Flechsig claims that the crossed and direct portions may assume vicarious relations; the direct portion may preponderate over the crossed, nay, may absorb it entirely. This may be bilateral or unilateral. No confirmation has yet been offered for the latter view, but it is not improbable.

The pyramid tract is better developed in man than in any other animal. It is one of the latest to attain maturity in the new-born infant. It is defective in idiots, and absent in microcephali. It is present only in those animals who have free motor control of the extremities. It is undemonstrable in the cord in lowest animals. It is absent in the elephant and whale. These facts collectively, even if there were no pathological evidence pointing in the same direction, prove that it is the channel through which the motor area of the cerebral cortex is placed in communication with the muscles of the extremities of the opposite side, thus mediating intelligent motor activity of the latter.

The tract which originally constitutes a part of the Rolandic loop, and is located in the genu of the internal capsule, lies mesad of the pyramid tract in the pes.* It leaves the pes to break the demarcation line, entering the tegmentum.† Here it lies in the angle between tegmental lemniscus and demarcation line (Figs. 4805, 2 and 4826, 11). Caudad it becomes lost, either in the reticular formation or after rejoining the pyramid tract in the upper part of the oblongata. This the *[illegible] tract* is in all probability the channel through which the facial and hypoglossal nidi are placed under the dominion of the opposite cerebral hemisphere.

Further details regarding the cerebro-spinal fibre systems will be found in the article Spinal Cord.‡

In previous [illegible] the articles relating to [illegible] are as follows:

Vol. I.

Development of the Brain, pp. [illegible]. H. S. [illegible]
[illegible] M. Allen Starr.
[illegible] Mary Putnam Jacobi.

Vol. II.

[illegible] pp. [illegible] W. B. Scott.
Cranial Nerves, pp. [illegible] Frank Baker.
[illegible] M. Allen Starr.

Vol. V.

[illegible] Nerve, Fig. [illegible]
[illegible] Localization of [illegible] M. Allen Starr.

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* [illegible]
† [illegible]
‡ [illegible]

* [illegible] it is even a question whether [illegible]
† [illegible] Meynert [illegible]
‡ [illegible] a distinct course from [illegible]

Vol. VII.

Thalamus Opticus, pp. 49-52. B. Sachs.

Vol. VIII.

Gross Anatomy of the Brain, pp. 107-164. B. G. Wilder.
Malformations of the Brain which are Morphologically Instructive, pp. 189-194. B. G. Wilder.
Pacchionian Bodies, pp. 194-195.
Removal, Preservation and Dissection of the Brain, pp. 195-201. B. G. Wilder.
Surgery of the Brain, pp. 201-231. W. W. Keen.
Vessels of the Brain, pp. 231-244. W. Browning.

E. C. Spitzka.

BRAIN, MALFORMATIONS OF, WHICH ARE MORPHOLOGICALLY INSTRUCTIVE.—In Vol. I., pp. 654–656, and in Vol. III., pp. 735–738, encephalic malformations are considered mainly as affecting the viability of the individual. In the present article are given figures and brief descriptions of certain conditions which illustrate in some degree the normal structure and development of the organ as presented from a morphological point of view in the articles on its Development (Vol. I., pp. 633–642) and Gross Anatomy (this volume, pp. 107–164). Did space permit, the number of cases might well be increased almost indefinitely, for it is scarcely possible to imagine any encephalic malformation that may not suggest, illustrate, or apparently contravene some morphological idea. On this account it is to be the more regretted that so few such specimens are adequately preserved, examined, figured, described, and explained; indeed, no case is known to the writer in which the best possible use has been made of the opportunity; it is particularly desirable that, when malformation is suspected, the brain be thoroughly hardened by alinjection (injection of alcohol) of both the arteries and the cavities; see the article in this volume, Removal of the Brain. The accounts and explanations of the following cases are not altogether satisfactory to the writer, who believes it necessary to make careful comparisons of several exhibiting different degrees of the same general kind of malformation.

§ 1. Prop. I. In infantile hydrocephalus there may persist a relative extent of the cavities, and a tenuity of the parietes which normally characterize the earlier embryonic stages with man (Fig. 4693), and the adult conditions of certain low or generalized vertebrates (Amphibia, Fig. 4739, and Dipnoans), while yet the parts are large enough to be more easily studied than those embryonic or animal brains.

§ 2. Points illustrated by Fig. 4830. A. The fundamental morphological relation of each hemicerebrum as a lateral outgrowth, process, diverticulum, or "wing" of the mesal portion of the prosencephal.

B. The non-formation or obliteration of all the fissural corrugations and inequalities, excepting the Sylvian, which is a mere shallow depression extending obliquely dorso-caudad along the lateral aspect of each hemicerebrum.

C. The enormous size of the porta,* yet the maintenance of its complete circumscription.

D. The tenuity of most of the parietes; in the occipital region they are no thicker than a sheet of ordinary paper, and are really exaggerated by the two ink lines and intervening space.

E. The extraordinary distinctness of the mass named *caudatum*, of which another view is given in Fig. 4831.

F. The peculiar form and relations of the rounded mass intervening between the caudatum and the lateral wall, and which may represent the lenticula.

G. The non-appearance of the thalamus in the floor of the paracœle.

H. Upon the whole, the retention, substantially, of a condition of the cerebrum comparable with the normal state at a much earlier period of development; it is, as it were, an expansion of such a cerebrum as exists at twelve weeks; see Fig. 4708.

§ 3. Points illustrated upon Fig. 4831.—A. The great size of the porta in this hydrencephal; its ventral half is concealed by the caudatum, but the total length (dorso-ventral dimension) is 19 mm. (three-fourths of an inch), and its width 8–9 mm.

B. The complete circumscription of the porta, notwithstanding the delicacy of the parts and the pressure that may have caused its enlargement.

C. The great extension of the paraplexus and adjoining portions of the parietes; the parts marked 6 and 7 are membranous; the zone just caudad of 7 and forming part of the upper margin of the figure may be the fimbria, and the thicker zone just caudad of it may be the hippocamp.

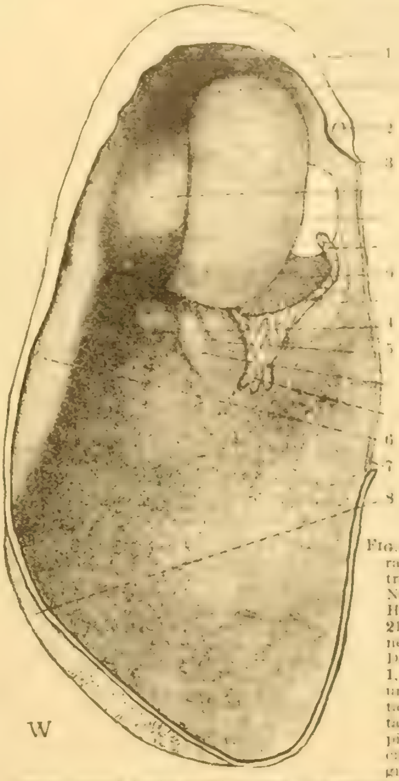

FIG. 4830.—The Left Paracœle (Lateral Ventricle) of a Human New-born (7 Months) Hydrocephalus. No. 2131, Museum of Cornell University. 1. Drawn by Mrs. W. [illegible] 1, One of several slight undulations of the cortical surface in the frontal region; 2, small pit, probably artificial; 3, cephalic margin of a break, apparently natural, in the mesal parietes; the ventral margin of this break is indicated by 7, and the corresponding caudal margin projects slightly mesad just caudad of the line; it may be supposed that this interruption of the mesal wall represents the location of the callosum that might have been formed; 4, 5, slight elevations as yet undetermined; 6, distinct though rounded ridge corresponding to the shallow Sylvian fissure, the only recognizable fissure; 7, see 3; 8, occipital end of the hemicerebrum, projecting slightly beyond the cut surface; 9, membranous portion of the parietes (perhaps an attenuated tenia) through which the thalamus shows.

Preparation.—The child was supposed by the physician and parents to be seven months advanced; it breathed a few times; the weight was 1,618 grams. The neck and scalp were swollen, but the head was not unusually large. Normal salt solution was injected into the umbilical vein and escaped, with blood, from the [illegible]. Then half a litre of ninety per cent. alcohol was injected, the [illegible]. The scalp, calva, and dura were removed, and the head suspended in brine while the brain was extracted; in spite of care there was some separation of the hemicerebrums at the meson. The contained fluid was allowed to escape, the brain placed in ninety per cent. alcohol, and the hemicerebrums inflated to their natural size. They were then covered with a thin layer of absorbent cotton to keep them [illegible]. The alcohol was changed twice at intervals of two days, and in [illegible] month the various sections were made under alcohol. The mass supposed to represent the caudatum was extremely dense. The [illegible] firm, and in parts more substantial than the [illegible]. The condition of the diencephal was not fully determined. The [illegible] seemed to be wholly occluded, which would account for the [illegible] of the cerebrum. The entire specimen needs further study and comparison with similar cases.

§ 4. Prop. II. In adult hydrencephals, although the parietes are thickened approximately as in the normal brain, the existence and connections of the cavities are more readily observed, and certain parts, ordinarily insignificant, become relatively more conspicuous

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* For more common equivalents of unfamiliar terms, see the Index, and the article Gross Anatomy of the Brain.

§ 5. Points illustrated upon Fig. 4832.—A. Several points illustrated upon Figs. 4734 and 4735 in the article Gross Anatomy of the Brain.

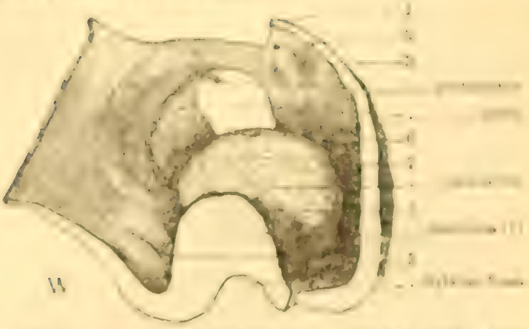


Fig. 4832.—Lateral Aspect of the Right [illegible] (Hydrocephalus). [illegible]

[illegible] [illegible] Fig. 4833, the paraplexus on this side was [illegible].

B. The relation of the paraplexus to the cella and medicornu.

C. The completeness of the paracoelian floor after the removal of the thalamus: the interval, rima, between the [illegible] and the lateral margin of the fornix (fimbria) is completely filled by the plexus and the membranes (pia and endyma) from which it is produced.

D. The greater width of the rima in the cella than near the end of the medicornu.

E. The extension of the postcalcarine fissure (stem of united occipital and calcarine) across the hippocampal gyre; it does not, however, reach the hippocampal fissure.

§ 6. Points illustrated by Fig. 4833.—A. The size, form, and direction of the porta from the mesal aspect.

B. The complete circumscription of the porta, caused by the reflection of the endyma upon the intruded plexus (Fig. 4745).

C. The greater length of that part of the paraplexus which hangs in the porta (portiplexus) than of that which hangs in the aula (auliplexus).

D. The constitution of the velum as a fold of pia, with blood-vessels intervening; one lamina of the fold belongs to the fornix, and the other to the thalamus, or rather to the diatela or primitive diacoelian roof (Fig. 4765).

E. The relation of the ventral end of the porta to the aulix ("sulcus of Monro").

F. The thinness of the fornicommissure (for [illegible]).

G. The length of the crista connecting the callosal rostrum with the fornix.

H. The extension of the [illegible] and of [illegible] the hemicerebrum. It is uncertain how far this existed normally, or was produced by the process of [illegible].

I. The continuity and apparent identity of the thin cephalic wall of the mesal cavities represented by the [illegible], the [illegible], and the [illegible]. Morphologically, however, these have distinct relations, as stated on p. 1[illegible], § 144.

§ 7. Page 111. Callosal [illegible].—In addition to about fifteen cases of absence or thinness of the callosum, there have now been reported at least twelve instances of its complete absence, together with the mesal part of the fornix. Commonly this deficiency was accompanied with mental and physical weakness amounting [illegible]; but Malinverni reported (*Giornale* [illegible] *Acad.* [illegible], 1874; *Gazette Médicale de Paris*, January 16, 1875; *Gazetta delle Cliniche*, 1874, No. 15; *London Medical Record*, 1874, No. 73) the case of a soldier forty years of age, who had been noted merely for irritability, taciturnity, and lack of [illegible]. The last instance to be recorded is that of Onufrowicz (*Arch. für Psychiatrie*, xviii., 1887) who refers to the literature of the subject very fully. To a certain extent these [illegible] brains represent on a larger scale the stages in mammalian development before the hemicerebrums are connected by the callosum and the fornicommissure. Likewise the permanent conditions of the brains of the monotremes, marsupials other than [illegible], where the callosum and fornix are absent or rudimentary; see the papers of H. F. Osborn (*Morphologisches Jahrbuch*, xii., 223-251, and 530-543).

§ 8. Points illustrated upon Fig. 4834.—A. The absence of the callosum and of the fornicommissure (mesal part of fornix).

B. The development of the fimbriodentum as far dorsad as a point corresponding apparently to the dorsal limit of the aula and porta (which is not distinctly indicated).

C. The roofing in of the aula and diacoele by a thin membranous [illegible] tela, the remnant of the primitive roof of the cavities.

D. The absence of the medicommissure and small size of the precommissure, in contrast with the same parts in the [illegible] cat (Fig. 4835).

E. The independence of the occipital fissure, and the apparent junction of the calcarine with the hippocampal.

F. The radial disposition of the mesal fissures; some

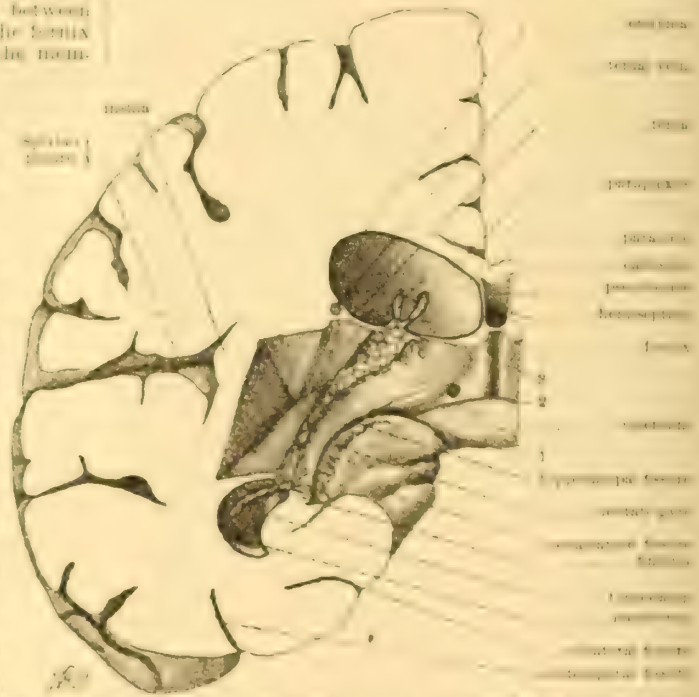


Fig. 4833.—Transection of the Right Hemicerebrum of an Adult Hydrocephalus. [illegible]

[illegible]

of them probably represent the transitory fissures mentioned in vol. i., p. 640, and shown in Fig. 4757, 2, 3, 4.

§ 9. Prop. IV. Among other mammals than man the abnormal absence of the callosum has been observed, so far as known to the writer, only in three cats examined in the anatomical laboratory of Cornell University; one of these cases is represented in Fig. 4835.

§ 10. Points illustrated by Fig. 4835.—A. The total absence of callosum and fornix (its mesal part) in a cat apparently nearly grown and not markedly peculiar.

B. The normal development of the fissures, excepting, of course, the callosal and—presumably—the dorsal end of the hippocampal; contrast the fissures in the incallosal human brain, Fig. 4834.

C. The retention of so much of what is commonly called *fornix* as pertains to the primitive condition of a mammalian brain, viz., the prosoterma (dorsad of the precommissure) with its retreating margin, to which, doubtless, was attached the original thin roof of the mesal aula and diacœle.

D. The unusual size of the precommissure and medicommissure, as if to compensate for the absence of the callosum. In a normal cat's brain (No. 342) where the hemicerebrum is 35 mm. long, the precommissure is 1.8 mm. in

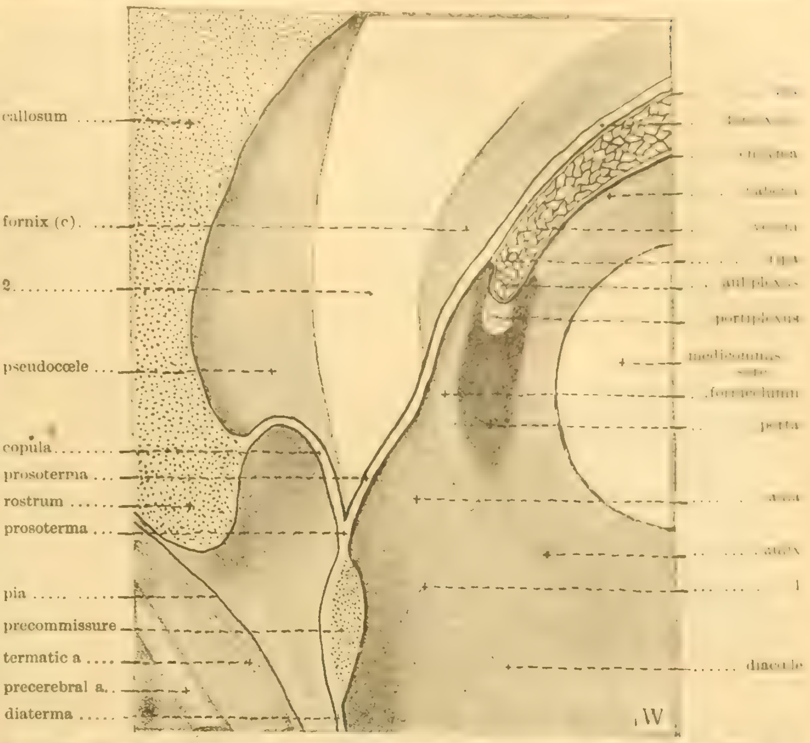


FIG. 4833.—The Right Porta and Adjacent Parts, seen obliquely from the Caudal Side. 385; [illegible] 1. Drawn by Mrs. Wilder. The lateral aspect of the left porta of the same brain is shown in Fig. 4742, under which the mode of preparation is described. 1, Dotted line from the ventral end of the porta to the ventral margin of the precommissure, and assumed to demarcate the diacœle from the aula. 2, part of the mesal surface of the hemiseptum, unusual and not fully understood. See § 6.

Defects. The area marked 2 is not a cut surface, as its plainness would indicate; it was shaded lightly in the drawing, but became blank in the engraving. The extent of the pseudocœle and the length of the copula are so unusual as to be anomalous; these peculiarities, however, do not materially affect the porta, which is the important feature of the figure. The dots indicating the fibrous constitution of the callosam and precommissure are too heavy and too closely placed.

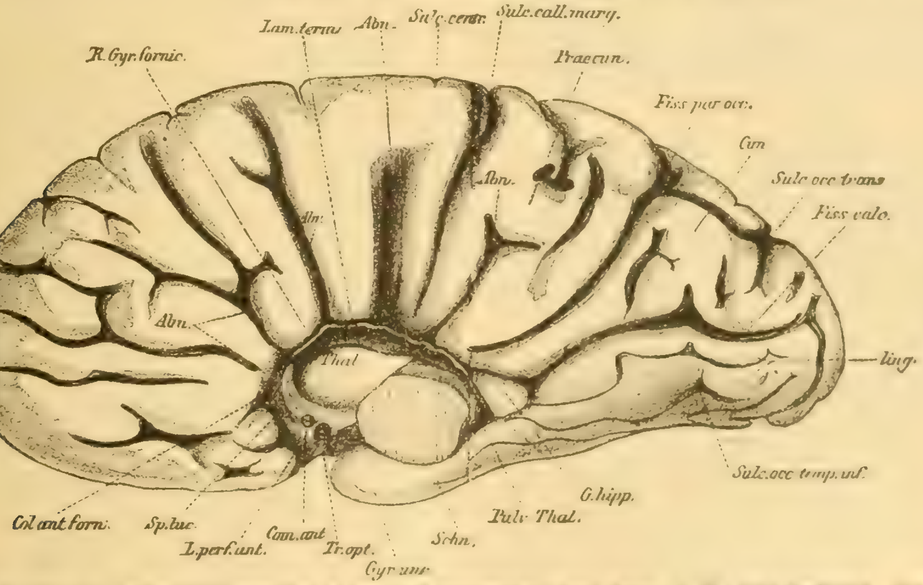


FIG. 4834.—Mesal Aspect of the Right Hemicerebrum of an Incallosal, Microcephalic, Adult Brain. × .93. From Onufrowicz. *Abn.*, abnormal radiating fissures; *Col. ant. forn.*, fornicolumn; *Com. ant.*, precommissure; *Cun.*, cuneus; *Fiss. calc.*, calcarine fissure; [illegible] fissure; *G. hipp.*, hippocampal gyre; *G. unc.*, uncus; *L. perf. ant.*, precribrum; *Lam. term.*, terma [illegible] gyre; *praecun.*, precuneus; *Pulv. Thal.*, pulvinar (of the thalamus); *R. gyr. fornic.*, margin of the callosal [illegible] surface between the diencephal (thalami, etc.) and mesencephal (gemina); *Sp. luc.*, hemiseptum [illegible]; *Sulc. centr.*, central fissure; *Sulc. occ. temp. inf.*, collateral fissure; *Sulc. occ. tr.*, "transverse occipital fissure" [illegible]

Preparation.—This was the brain of a male idiot, thirty-seven years of age, who had never [illegible] obtained fresh early and well preserved; the paper ("Das balkenlose Mikrocephalengehirn Hofmann," *Arch. f. Psychiatrie*, [illegible], pp. 1-24), from which the figure is taken, is by Onufrowicz, but this and most of the other figures are by Forel. [illegible] of distinct indication of endymal continuity renders them less instructive than they might have been. [illegible]

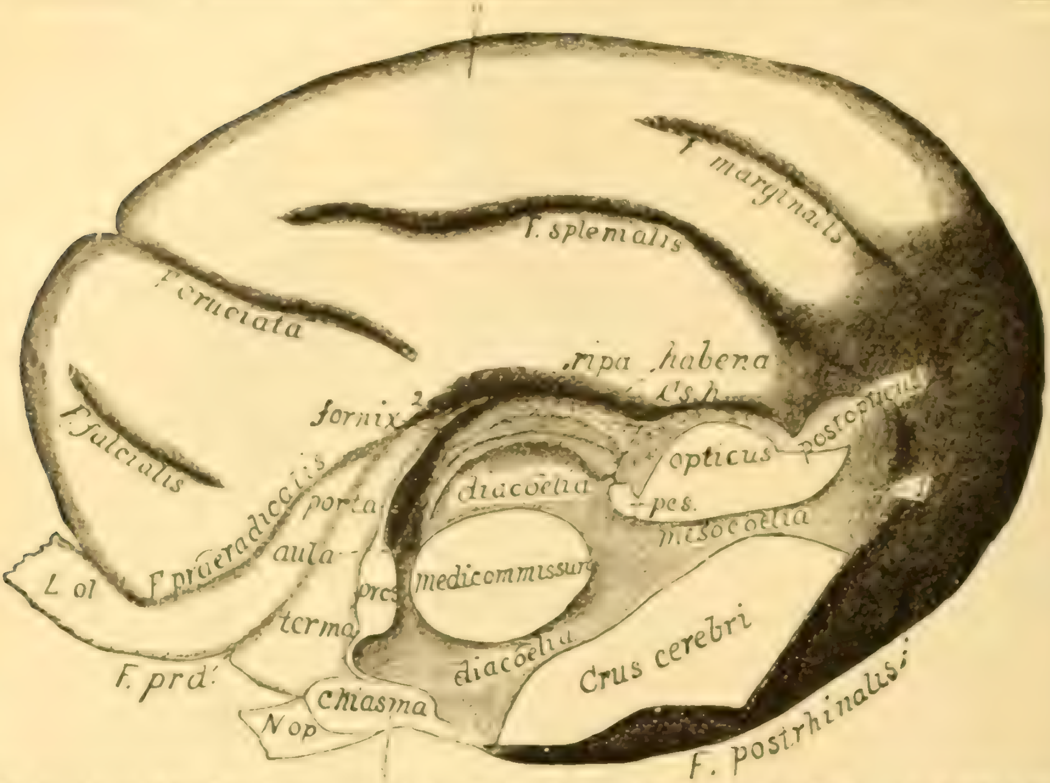


Fig. 4885.—Mesal Aspect of the Right Hemicerebrum of an [illegible] Cat's Brain. 381 × 4. From the writer's paper in American Journal of Neurology and Psychiatry, August, 188[illegible]. [illegible]

[illegible]

dorso-ventral diameter, and the medicommissure 3.8 × 4.2. In this [illegible] brain the length of the hemicerebrum is 33 mm., 2 mm. less than the other, yet the commissural dimensions are all greater, viz., 2.2, 4.2, and 5.2.

§ 11. Prop. V. The cerebrum is sometimes represented by a mass exhibiting only a partial division into a mesal and two lateral portions. This is the case with the not very rare cyclopian monsters, and with the brain described by Turner (Fig. 4887). Such brains are comparable with the earliest condition of the mammalian prosencephal and with the corresponding region in fishes.

§ 12. Points illustrated upon Fig. 4886.—A. The increase of the first (prosencephalic) vesicle in size and in the thickness of its parietes. As shown in Fig. 2 of the original paper, the floor and cephalic wall of the mesal region are seven to eleven millimetres thick, supposing the parts to be of natural size.

B. The subordination of the lateral extensions to the mesal portion of the prosencephal; they do not, as in the normal brain, extend cephalad of the mesal boundary, but merely laterad, caudad, and to a certain extent ventrad, so as to partly overlap the mesal portion.

C. The partial formation of fissures, one of which may represent the Sylvian.

D. As stated in the text, the prosencephalic cavity is single, i.e., not divided by constricted orifices (portas or "foramina of Monro") into a mesal aula and lateral paracoeles. In this respect, the cyclopean brain may be compared to the normal brain of fishes (Ganoids and Teleosts).

E. As also stated and shown in the paper, but not upon this figure, what the author regards as the [illegible] forms a very large and thin-walled vesicle on the dorsal aspect.

§ 13. Points illustrated upon Fig. 4887.—A. The possibility that an individual should reach maturity with a cerebrum so nearly undivided. Substantially, the presen-

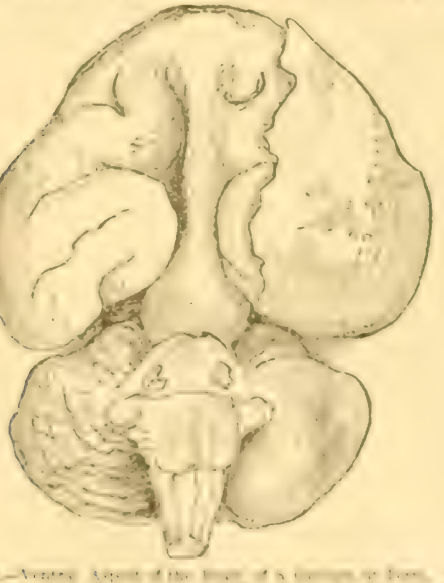


Fig. 4886.—Ventral Aspect of the Brain of a [illegible]

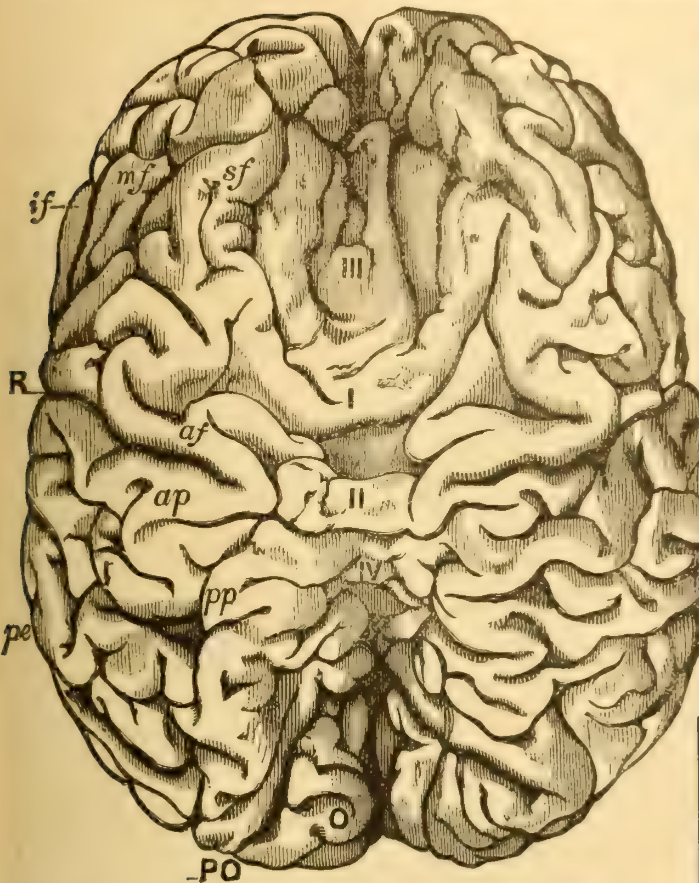
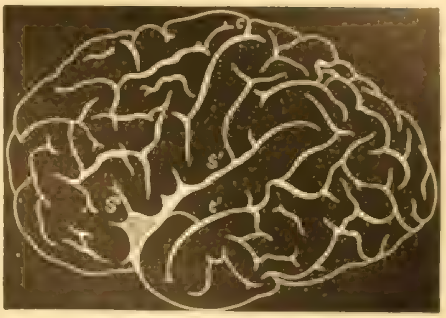
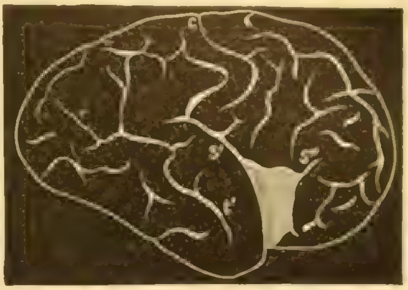


FIG. 4837.—Dorsal Aspect of an Imperfectly Divided Cerebrum; × .7. (From Turner, *Journal of Anatomy and Physiology*, xii., January, 1878, pp. 241 253.) *af*, Precentral gyre; *ap*, postcentral gyre; *if*, subfrontal g.; *mf*, medifrontal g.; O, occipital lobe; *pe*, "convolution of parietal eminence"; PO, occipital fissure; *pp*, "postero-parietal convolution"; R, central fissure; *sf*, superfrontal gyre; I, II, mesal transverse gyres, nearly at the level of the adjoining hemicerebrum; III, sloping cortical surface; IV, mesal gyres at a lower level than I and II.

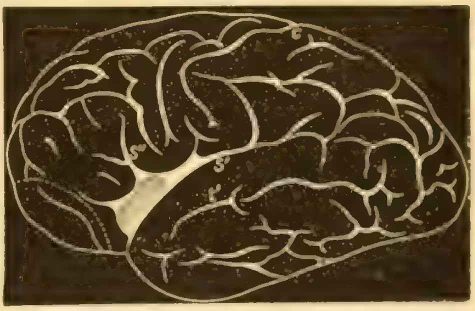
Preparation.—The brain was taken from an epileptic imbecile, male, forty-eight years of age, 146.7 centimetres (four feet ten inches) high, and weighing 55.7 kilograms (123 lbs.). The entire brain weighed 1,111.7 grams (39¼ oz.), of which the cerebrum constituted 978 grams (34.5 oz.). Most unfortunately this rare, if not actually unique, specimen was simply placed in alcohol, which was not changed; hence the base was ill-preserved and the ental features, although described in some detail by Turner, cannot be fully understood. A transection disclosed a single, mesal, cerebral cavity, about five centimetres wide, the floor of which is said to have been "formed of the upper surfaces of the corpora striata and optic thalami, which bodies were related to each other and to the *tænia semicircularis*, as in a normal brain;" yet "the third ventricle opened freely into the cerebral cavity along the middle of the floor." It is to be hoped that figures and more detailed descriptions may be published respecting the structure of this remarkable brain. A good abstract of the original paper is given in *Brain*, I., 133-134, April, 1878.



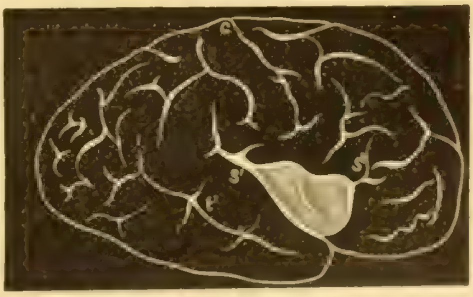
A. Left head, left hemicerebrum.



B. Left head, right hemicerebrum.



C. Right head, left hemicerebrum.



D. Right head, right hemicerebrum.

FIG. 4838.—Lateral Aspects of the Four Hemicerebrums of a Male Human Dicephalous Born at Term. (From the writer's paper in *American Assoc. Science Proceedings*, [illegible].) C, Central fissure; S', Sylvian fissure; S'', presylvian fissure; t', supertemporal fissure; the shaded area represents the insula. The dotted line on C indicates a part [illegible] in the removal.

Preparation and Defects.—The hemicerebrums were placed separately in alcohol, resting upon [illegible]; hence they flattened somewhat [illegible] the two right hemicerebrums were [illegible] the insulas are too much exposed. The [illegible] permit the representation of [illegible].

cephalic vesicle has not only increased in size and in parietal thickness, with but slight differentiation into a mesal and lateral masses, but the entire mass has developed fissures and gyres after the usual pattern, in general, excepting that certain gyres cross the meson; *a priori*, indeed, it is not clear why such a brain should not be efficient for mental as well as bodily manifestations.

§ 14. Prop. VI. It is well known that in no two individuals are the fissures and gyres exactly alike in all respects; also that the two halves of the same brain always present differences more or less decided, although they are seldom described or figured in detail as was done by Mills for several peculiar brains (*Journal of Nervous and Mental Disease*, XIII., September and October, 1886). Between individual variation and lateral variation within the same brain, come a group of variations which are seldom noted, viz., those that distinguish the two sides of the two brains of a monster with two heads (Fig. 4839).

§ 15. Points illustrated upon Fig. 4838.—A. The usual lack of fissural and gyral symmetry between the two sides of the same cerebrum.

B. The readily recognized distinctions between the two cerebrums of these closely associated individuals.

C. The superior fissural complexity of the two left hemicerebrums.

D. The resemblance of the right hemicerebrum of the left head to the left hemicerebrum of the right head, in the parieto-occipital concavity of the central fissure.

E. The right hemicerebrums were really the larger, but are shown smaller because they dried and shrank somewhat while drawing. The weights are as follows:

Left head	Left hemicerebrum,	182	372	768
	Right "	190		
Right head	Left "	196	396	
	Right "	200		
Two right hemicerebrums		390		
Two left "		378		

The entire body weighed 5,000 grams, the ratio being about as 1 to 6.5. The greater size of the right brain may be associated with the greater size of the entire right body, and with the fact that the intermediate leg, although approximately symmetrical and belonging, of course, to both sides, is projected toward the left of the single body, and is therefore more decidedly a left leg of the right child, than a right leg of the left child.

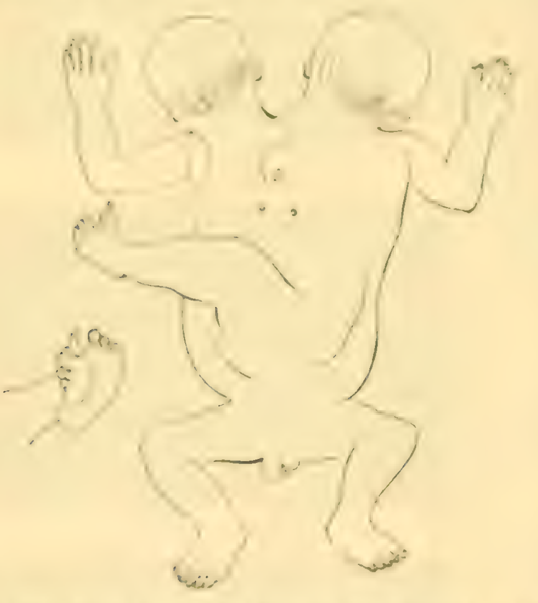


FIG. [illegible].—Dorsal Aspect of the Dicephalus, the [illegible] [illegible]

§ 16. Points illustrated upon Fig. 1839.—A. The greater size of the right head and body, and the sinistral projection of the third, common, leg.

B. The presence of two nipples on the dorsal aspect, caudal of the arm pits.

C. The partial duplicity of the right pelvis.

Burt G. Wilder.

BRAIN: PACCHIONIAN BODIES. These granulations, also falsely called glands, were perhaps first mentioned by Willis (1676), then by Meyer (1701), and almost simultaneously described by A. Pacchioni. They start as minute spheroidal, partially vesicular outgrowths (villi of Luschka) from the arachnoidal layer of the pia—where it bridges fissures as well as where it rests on the gyres—retaining its epithelial covering. They must not be confounded with granulations of the choroid or ependyma, with vegetations notably in the cavernous sinus (Hyrtl, 1862), nor with granular cauliform excrescences of the meninges seen in inflammations. They are often clustered, become pedunculated, penetrate the opposed dura, and finally project into the overlying venous channels, and even excavate (in part repel) the bone. They are usually most abundant opposite the middle of the falcial sinus—more correctly opposite the largest parasinual spaces—but may occur on both sides, along nearly the whole length of this sinus, beside the transverse and tentorial sinuses, and even beneath the latter, also in the temporal fossa opposite the trunks of the meningeal vessels and the frequently present temporal sinus. They occur not rarely (Luschka) and even further from the sinus along the line of large [illegible] veins after the latter have left the pia, and also at one point near the frontal border of the parietal bone, probably where a meningeal artery bends to connect through the skull with temporal vessels. Hence, in general, they occur opposite intradural blood-channels of some size, and especially those subject to continual variations in calibre (pulsation, ebb and flow). Their prevalent growth toward and into venous spaces has led to the assumption that the granulations themselves were venous structures or opened into such (Key and Retzius, Krahmer, and others). It is not true that Trolard claimed this. But it is now generally recognized that the injection of the spaces through the granulations must have been effected by the rupture of granulation vesicles.* From the intimate connection of the older granulations with the spaces they become darker colored, or, on tearing the two structures apart, flecked with blood. But the younger free corpuscles are pale, whitish.

The parasinual spaces are said rather to diminish with age, while the granulations certainly increase. Up to the twentieth year they are rarely developed to any extent. In congenital defect of the heart, they appear early and excessive (case of Luschka, 1860, one of the writer). However, at all ages continuous or intermittent compression of the brain space, of whatever origin, is the most frequent cause of their over-development. Under this head fall intra-cranial tumors of any kind or seat. Repeated congestion, as in chronic alcoholism, is also an accepted factor, doubtless acting mechanically. Various systemic troubles, as nephritis and diabetes, favor the enlargement of these bodies, possibly by unusual variations in the encranial pressure.

In view of all the facts—viz., that while these corpuscles regularly occur opposite intradural (extra-arachnoidal) blood-channels (not necessarily venous), their growth is especially favored on the one hand by venous stasis, on the other by pressure from the side of the cranial space—it is evident that they result from the oft-repeated local oscillation of the arachnoid. As the cerebrospinal fluid is subarachnoidal, it, especially when under pressure, forces that membrane at its weakest points into any depression, as that beside a dilated vessel; *the granulations always grow away from the cranial cavity, never toward it.* When, then, the favoring condition—be that even negative instead of positive—relaxes, the granulations to the extent that they have formed press against and penetrate superimposed structures, the continuous alternation of the conditions as continually favoring the process. This, as we believe, clear and simple explanation suffices for all the main features of these little growths.

PATHOLOGY, CLINICAL HISTORY, ETC.—(a) Like the wrinkling of the skin, the turning gray and falling out of the hair, and many other processes, the granulations themselves should only be considered pathological when they become excessive or develop prematurely. (b) Calcification or ossification of these bodies is not unusual. They may contain deposits of so-called brain-sand and even fat-globules. (c) When they penetrate into blood-spaces and even a sinus, they so far interfere with the return current, and also favor thrombosis (only one case of the latter, Förster's, has been attributed to this cause). (d) Foveæ glandulares, sharp depressions or excavations in the inside of the skull (preceding e and f), quite analogous to that seen in aneurism of a dural artery, are sometimes found. From their more or less intimate relations with the sinus-walls, Allen advises avoidance of the middle line in all operations upon the skull-cap. However, the diploë itself is never opened by these growths, as a new layer of bone always forms around the foveæ. (e) Small flat elevations of the external plate of the skull, opposite the foveæ, and hence near the superior median line, are mentioned by many. (f) Very rarely complete perforation of the cranium occurs.

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* This is a matter of interest in connection with the theory of [illegible] [illegible] [illegible] through the granulations [illegible] ignores or argues against the existence of such discharge.

1. Case of Weber-Ribes (1819; v. Pozzi); hole small, and covered by ligamentous membrane. 2. Luschka (p. 116); perforation of squamous portion of temporal bone. 3. Lecat (v. Heineke in Pitha-Billroth); pneumatocele capitis; skull at some points perforated by granulations of the dura. 4. Demme (1862; v. Mastin, "Venous Blood-tumors of the Cranium." Reprint, 1886). "On the left of the sagittal suture (posteriorly) was a sharp-edged opening the size of a cherry-stone, through which protruded a Pacchionian granulation." 5. The writer's observation. Man of forty; had suffered over three years from a tumor of the brain; autopsy, August, 1887. At the favorite spot near the frontal border of the parietal, somewhat removed from the sagittal suture, there was a clean-cut, complete perforation of the skull by Pacchionian granulations. This was circular, fully ½ ctm. across, surrounded even in the diploic portion by smooth continuous bone, and covered by periosteal membrane. At the border there was a very trifling over-projection of the outer bone-plate.

It is recognized that such perforations—even when incomplete—may, from local injury, lead to the formation of epicranial blood-cysts, inasmuch as the causative granulations usually traverse some blood-channel.

(g) In a few cases growths of this class have pressed on passing nerves, causing local neuralgic or paretic symptoms. Though it has been claimed that at times these growths induce headache, it is probable that they are then but co-effects of some other cause. (h) In animals generally these corpuscles are not present (brains of sheep, calf, rabbit, dog, and cat examined). Luschka found them only in the horse.

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William Browning.

BRAIN, REMOVAL, PRESERVATION, AND DISSECTION OF. § 1. This article has no direct reference to microscopical or pathological requirements;* nor is it designed for neurological specialists, or for those who may have the benefit of their counsel or access to large libraries; but physicians and students at a distance from medical centres, who desire to attain a real and personal acquaintance with the gross anatomy of the human brain as an aid to the comprehension of its minute structure, its functions, diseases, and mental relations, may profit from an account of the methods found useful in a laboratory where most of the students are preparing for a medical course.† That the procedures in vogue six years ago were not altogether satisfactory is evident from the vigorous animadversions in *The American Journal of the Medical Sciences* for January, 1883, pp. 228 and 229, by Professors Harrison Allen and Charles K. Mills. Notwithstanding evidences of progress in certain metropolitan schools the writer apprehends that his "pen-picture" of five years ago (*New York Medical Journal* and *Medical Record*, February 23, 1884) may not be altogether without warrant at the present time.

§ 2. The more important of the macroscopical methods of studying the brain, pursued in the Anatomical Laboratory of Cornell University, are summarized in the following paragraphs; from the nature of the case a strictly logical sequence is impracticable; certain of them are subsequently described in detail.*

§ 3. Before dealing with the human brain the various processes of removal, preservation, and dissection are practised upon the much more accessible brain of the domestic cat (Figs. 4698, 4710, and 4729): "*Fiat experimentum in corpore vili.*"†

§ 4. Fœtal and infant brains are utilized not only for what is learned from them as such (Figs. 4697 and 4715), but also as preliminary to dealing with the less readily procured and removed adult organ.

§ 5. Skulls—which may be purchased or easily prepared under nearly all circumstances—are less esteemed than brains; the "kernel" is more highly valued than the "shell."

§ 6. The infant cranium is divided with scissors and nippers (Fig. 4881), or softened by ten per cent. nitric acid‡ so as to be cut with the knife; Fig. 4748.

§ 7. The common method of dislodging the calva (calvaria or skull-cap), after the circular cut with the saw, by "inserting a strong hook and giving a quick jerk," is held to be artistically brutal and anatomically futile; a second, sagittal, section is made, and the calva removed in two pieces; § 66.

§ 8. Excepting for special reasons the dura is retained until the calva is removed and, if possible, is extracted with the brain; Fig. 4711. With care and anatomical knowledge the dura may commonly be retained excepting over a limited central area of the base of the brain.

§ 9. The fresh brain is removed over brine (saturated and filtered), supported in it during the operation, and kept in it until its final disposition is made.

§ 10. A fresh brain in the dura is lifted by the latter and supported in liquid by attaching cords to the dural edges, the other ends of the cords being carried over the rim of the pail or other vessel and wound about hooks, or otherwise attached.

§ 11. A fresh brain deprived of its dura, if it is to be either studied from any aspect or injected into the arteries or the cavities, is supported and steadied in a pail of brine by passing under it a towel or broad strip of cloth, the ends of which are secured to the pail by hooks.

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* See the articles Histological Technique (Vol. III.), Post-mortem Examinations (Vol. V.), and Histology of the Brain, this volume; also the volume by Bevan Lewis (1882), and papers by F. H. Dercum (1886), C. K. Mills (Med. and Surgical Reporter, February 3, 1883), and Spitzka (Jour. Nerv. and Mental Disease, July, 1883, p. 84).

† That these methods are fairly successful may be concluded from the facility with which these students receive the more advanced or specialized instruction imparted at the great medical schools, and from the nature of the preparations (more than 300 in number from the human brain and about 700 from animal brains) in the museum of Cornell University, some of which are represented in the article Gross Anatomy, pp. 107–164 of the present volume. Yet there is hardly one of these methods that is not susceptible of change for the better. Indeed, the constant effort to improve them has been a serious, and well nigh absolute, hindrance to the completion of this article.

* For fuller accounts of others, see the New York Medical Journal for February 23, March 1, and June 14, 1884, and (somewhat less complete) the New York Medical Record for the same dates; also the second edition of "Anatomical Technology."

Did space permit, the writer would gladly specify the sources of such of these methods as are not original, and the points in which efficient aid has been rendered by his students, past and present, in either carrying out his own ideas or in improving upon them; the following deserve particular mention: Professors S. H. Gage, B.S., M. J. Roberts, M.D., Theobald Smith, M.D., and H. F. Summers, B.S., Dr. W. C. Krauss, and Messrs. F. L. Kilborne, B.V.S.; B. L. [illegible], B.S., and [illegible].

† The dog's brain is recommended by Howell and by Foster and Langley, and that of the sheep by Morrell. The gross anatomy of the cat's brain and the modes of examining it are described in "Anatomical Technology," pp. 400–503; the extent to which the [illegible] material is utilized in imparting the elements of [illegible] may be seen from the fact that, in addition to the [illegible] supplied for examination to the laboratory [illegible] university, the general class in physiology [illegible] prepared cat's brain for every two members.

‡ Ordinary commercial acid is about 70 per cent.; the desired reduction is accomplished by adding five parts of water to one of the acid (by weight), or seven of water by volume. The specific gravity of the mixture is about 1.057. In any case the percentage of acid may be determined by the method recommended by Fresenius, second American edition, p. 688.

sacks, or otherwise, the brain may then be kept at any height in the brine, and rotated without removing it.

§ 12. The fresh brain is never allowed to bear its own weight or to rest upon a flat surface, but is supported in the calva[*] or in a bowl of appropriate shape, or in a liquid of equal or greater specific gravity.

§ 13. The use to be made of a brain is, if possible, determined upon in advance. If only part is to be employed for a specific purpose, the rest is cut away and preservative effort concentrated thereon.

§ 14. If the capillary and pial attachments are to be investigated, the arteries are injected and the parietes hardened by injection of strong alcohol into the [illegible] (§ 30 and Fig. 4686).

§ 15. If certain portions of the cavities are in question, free access of alcohol is gained by widely opening some other region, as, e.g., by cutting off a frontal, temporal, or occipital lobe.

§ 16. Unless there are special reasons to the contrary, brains are transected in the narrow region of the mesencephal (crura or optic lobes); the cerebral and cerebellar portions are then removed separately with greater ease and less risk of laceration. Each of these regions is medisected, if desired, more accurately than the entire brain can be, whether before or after hardening, and the two divisions of either half are subsequently apposed for study, or even attached for exhibition.

§ 17. When the mesencephalic region itself is to be preserved intact, by lifting the occipital lobes a little more the transection is made through the diencephal (thalami).

§ 18. For the study of fissures and gyres, the cerebrum (with the thalami) is commonly medisected (§ 19), and each half hardened by placing it on its mesal surface in a dish of forty-eight per cent alcohol (§ 64) in a cool place; a thin layer of cotton covers the bottom. After two days the specimen is turned upon its convexity, and cotton built up about it so as to obviate sagging and flattening so far as possible (Fig. 4778). The strength of the alcohol is increased by about five per cent at intervals of two days until it is ninety-five per cent.

§ 19. The fresh cerebrum is medisected as follows: A bed of cotton is made in a pail or dish of brine, and the cerebrum placed upon it, about one-third above the surface. With the fingers and scalpel-handle the arachnoid, which connects the opposed hemicerebral surfaces just dorsad of the falx (Figs. 4684, 4711, and 4750), is torn, and a layer of cotton introduced to keep the fissure slightly open down to the callosum. The cerebrum is then turned so that the chiasma (Fig. 4689) is uppermost; this, being broad, is first divided with a very sharp large scalpel; then the terma, fornicommissure, callosum, etc., by successive sweeps.

§ 20. When a separated head is obtained the brain is usually hardened in place by the continuous injection of alcohol (§ 68); it shrinks somewhat, but retains its natural proportions. Such a head, medisected with a sharp saw, is instructive in many respects (Fig. 2684). Sometimes sections are made in other directions or the calva removed as with the fresh brain (§ 60).

§ 21. For macroscopic purposes freezing is avoided, as tending to leave the mass friable.

§ 22. When the brain is to be hardened by immersion in alcohol without injection, as low a temperature as is attainable, above freezing, is maintained; see § 18.

§ 23. Alcohol is commonly employed as the initial preservative, excepting when it is necessary to differentiate the two kinds of nervous tissue.

§ 24. When the brain is to be preserved entire, alcohol (or other preservative liquid) is injected into the arteries by continuous pressure, and thus carried directly to the tissues (§§ 69 and 70).

§ 25. The surface of a fresh brain is never exposed to strong alcohol without a previous wetting with salt solution or water.

§ 26. The alcohol in which brains are stored is maintained at not less than eighty-two per cent, upon the alcoometer scale of Tralles (§ 64). Weaker alcohol is employed for the immersion of fresh brains, for soaking out the dark coloring matter from brains that have been hardened in Müller's or Erlicki's liquids, or for the preservation of other specimens requiring a less strength.

§ 27. When it is desirable to retain approximately the form of a brain that has been already deprived of its dura, it is hardened in some heavy liquid, e.g., Müller's or Erlicki's liquid (Vol. III., p. 663), or a saturated solution of zinc chloride ("Anat. Technology," p. 445).[*]

§ 28. Hydrocephalic brains, and those of fetuses between the second and seventh month, are alcoholized in place from the aorta or other artery, and also have the more or less abundant endolymph replaced by strong alcohol. This direct, encephalic alcoholization is done as soon as possible after the arterial has begun; it is most conveniently accomplished by making a slit at the margin of the prefontanelle large enough to permit the introduction of a cannula and the escape of liquid at its side. The injection need not be continuous, and, of course, should not be under pressure, but may be repeated at intervals of an hour or two.

§ 29. When a hydrocephalic or fetal brain is wanted for a special object involving the integrity of the entire cerebrum, or the complete distention of the metaporencephalic cavities, then the undesired region is cut away, the desired region left in the cranium, and the alcohol injected through the aqueduct, continuously, in order to make up for the non-injection of the arteries.

§ 30. Removed embryo and hydrocephalous brains are relieved from pressure during hardening by inflating the cavities (Fig. 4850). The buoyancy of even an adult normal brain is sometimes increased by injecting air into the arteries through a bulb-syringe.

§ 31. When it is desirable to differentiate the two kinds of nervous tissue, the brains are immersed in, or injected with, Müller's liquid or Erlicki's liquid, or a solution of bichromate of ammonium (Vol. III., p. 663) or a fine gelatine or glue mass (§ 32, note).

§ 32. When the larger vessels are to be studied Gage's modification of Pansch's starch mixture is employed ("Anatomical Technology," 2d ed., p. 140); if the ultimate vascular supply is in question, a fine gelatine mass is used.[†]

§ 33. When practicable the pia(arachnoid) is removed as soon as it loosens from the surface, which is commonly within two days after immersion; but this is not essential, for it may be removed at any subsequent period with merely somewhat more care against breaking or wounding the hardened brain.

§ 34. Alcoholic brains are examined before fresh ones.

§ 35. The encephalic cavities are explored and their connections and circumscription determined before the details of the parietes are considered.

§ 36. The size and form of the cavities are maintained and the preservation of their immediate parietes is assured by injecting alcohol into them (Fig. 4740).

§ 37. The forms of cavities are ascertained by making solid casts (Fig. 4741).

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[*] For the [illegible] of a [illegible], see § 62.

[*] By Giacomini and others a zinc chloride solution has been employed [illegible] preservation of the brain. [illegible] (Vol. [illegible], 541, 542).

[†] [illegible]

§ 38. Before attempting to comprehend large sections, involving perhaps several parts but distantly related excepting by topographical contiguity (Fig. 4751), the beginner makes dissections for the exposure of parts in their structural continuity; Figs. 4694, 4698, and 4711.

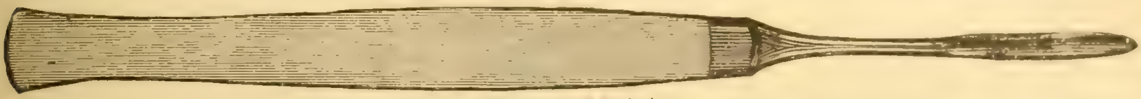
§ 39. Delicacy of manipulation is cultivated and a prompt check put to all forms of anatomical Philistinism, whether in word or deed; the student is urged to practise self-control, to restrain what Hyrtl calls the "*furor secandi*," and never touch his specimen except for a good and sufficient reason. From the ecclesiastical standpoint, perhaps, the "laying on of hands" cannot be overdone, but in practical anatomy its excess is likely to prove the reverse of a blessing. These cautions are called for in respect to the dissection of muscles, etc., to which the examination of the brain is as watchmaking to the wielding of hammer and tongs.

§ 40. In brain dissection, as in surgery, the knife is made the last resort; blunt points and blow-pipes are employed as long as possible. When cutting is to be done the aphorism of Dr. Holmes is recalled: "Let the eye go before the hand, and the mind before the eye."

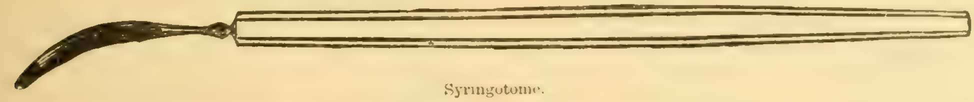
§ 41. Specimens that might be injured by falling upon a hard surface from the height of even a decimetre (four inches) are held during examination over a pad of cotton or a dish of alcohol, and carried from room to room in a vessel and not in the hand.

§ 42. Embryos and delicate brain preparations are dissected under alcohol, and sometimes pinned to a piece of cork loaded with sheet-lead; see Fig. 4748. Preparations including the medicommissure (Fig. 4727) are supported upon cork while making and for exhibition.

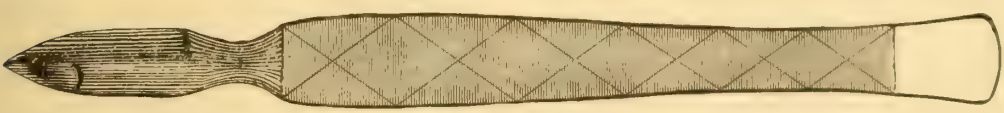
§ 43. To facilitate discrimination of natural from artificial surfaces, especially upon permanent preparations,



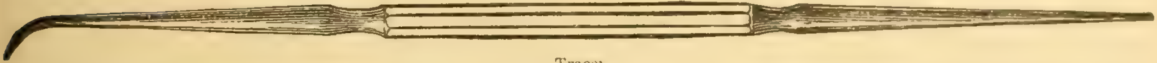
Blunt-pointed Scalpel.



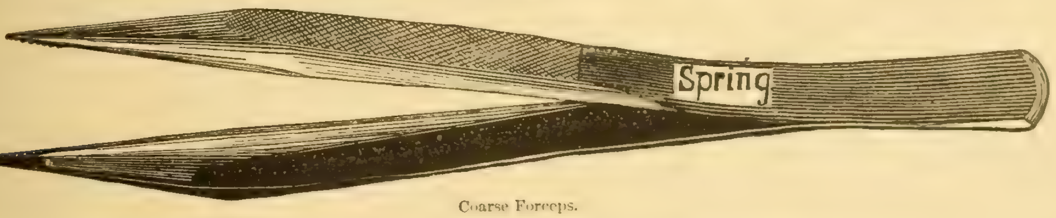
Syringotome.



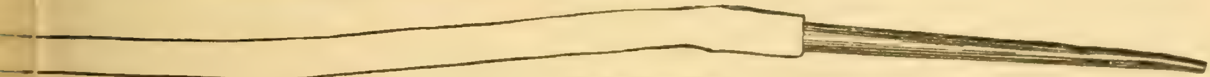
Arthrotome.



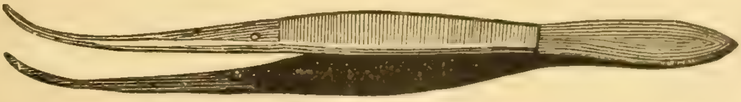
Tracer



Coarse Forceps.



Flexible Blow-pipe.



Fine Curved Forceps.

FIG. 4880.—Some of the Instruments Useful in the Removal or Dissection of the Brain. All of actual size. (From "Anatomical Technology.") The two upper are eye-knives; the syringotome is commonly called *canaliculus knife*; it is of great use for exploring orifices, the portæ ("Foramen of Monro") and the metapore ("Foramen of Magendie"), and for dealing with membranes and plexuses where a point or a prominent edge might do injury; it has been the writer's favorite instrument since 1866. The tracer may be employed sometimes in place of the [illegible] syringotome, but its chief use is in isolating nerves and vessels by tearing the connective tissue. Most forceps are too stiff and soon tire the hand or hinder delicacy of manipulation; the coarse "Coxeter" forceps represented have the blades excavated so as to be lighter than usual. The flexible blow-pipe is most readily made by attaching to a piece of rubber tubing, thirty to forty centimetres long, the smaller half of the metal blow-pipe commonly sold with dissecting instruments. The length of the tube enables the object inflated to be held at a convenient distance from the eye; since inflation is temporary injection, the advantages of witnessing the effects are obvious. A larger volume of air may be obtained by using the larger half of the metal pipe, and glass cannulas of any size may be employed. The arthrotome has the handle continuous with the blade, and the edge of the blade is rounded, excepting near the tip; it is practically a cartilage knife.

Besides the instruments shown in Figs. 4880 to 4882, the following, more familiar, are indispensable. Scalpels of three sizes, large for [illegible] medium for ordinary dissection; small ("Charrière") for finer dissection. Scissors, curved flatwise, three sizes. A hand lens, [illegible] or "linen-tester." A bone-chisel, or ordinary chisel of moderate width, or even a screw-driver sharpened slightly. A [illegible] bulb. Absorbent cotton; if common cotton is used it must be first thoroughly wet in alcohol or water. Caoutchouc rubber tubing [illegible] or T-tubes for branching of injection tubes may be had of dealers; the smaller end of a straight [illegible] methods of making and securing cannulas, and of making injections, are described in Vol. III., p. 684, and detailed in [illegible] pp. 137–148. Cheap and efficient pinch-cocks may be had in the form of the wooden, spring clothes-pin, which [illegible] wire cranes or used independently upon the tubes. As a guide in all operations involving the location of the [illegible] the cranium, figures are much less serviceable than either of the following: an entire brain hardened in the [illegible] *papier maché* model; a plaster model; a plaster cast of the cranial cavity. Excellent plaster casts of the cranial cavity [illegible] human races as well as of many other mammals, may be had at the Natural History Establishment of Professor H. A. Ward at Rochester, N. Y.

incisions always follow straight lines and meet at angles rather than join by curves; see Figs. 4880 and 4882.

§ 44. So far as possible, incisions of the brain are made in liquid or while the scalpel is irrigated: with hardened brains alcohol is used; with fresh a salt solution.

§ 45. Specimens which have become dry and distorted are immersed for a day in weak spirit (twenty-two per cent.), and then replaced in the strong alcohol.

§ 46. When part of a thin brain preparation (e.g., a hydrocephalous cerebrum like that shown in Fig. 4880) has dried, it is restored by placing on the spot a bit of absorbent cotton wet in water.

§ 47. To remove a delicate specimen from a vial, the vial is immersed in a dish of alcohol and the specimen floated out; to replace it, if the alcohol is clear, the vial is immersed and the specimen floated in; if turbid, the specimen may be transferred upon a bit of paper, a watch-glass, spoon, or upon card between the points of the fine curved forceps (Fig. 4880).

§ 48. Friable specimens are infiltrated with paraffine: see the paper by W. C. Krauss (*Buffalo Medical and Surgical Journal*, November, 1888) and publications therein referred to.*

§ 49. Defibrillation—the tearing of brain substance in the direction of the least resistance, so as to make "cleavage preparations"—is not regarded as affording conclusive evidence of fiber arrangement; but it is practised in illustration of facts determined by more exact methods, microscopical, pathological, and experimental.

§ 50. **The fresh brain is weighed as follows:** A vessel partly full of water, salt solution, or brine is balanced upon the scales; the brain is lifted from the liquid in which it has been, in the hollowed hands; they and the brain are rinsed with water, and the brain is transferred to the vessel on the scales. If the dura remains the weighing cannot be accurate, even by deducting its weight when removed.

§ 51. An effort is made to determine the usual or average loss of weight in alcoholic hardening by weighing the brain when fresh and after thorough hardening; see this volume, p. 163, § 285, etc.

§ 52. **Fresh brains, especially if in the dura, are transported** long distances in cool weather in a small pail of supersaturated brine; in warm weather even, if the brain is well cooled in advance and the smaller pail set in a larger and surrounded with rather large pieces of ice, a day's journey may be accomplished safely. Such open packages should be plainly marked "Specimens of Natural History. This side up with care."

§ 53. Already hardened brains are transported either in a small pail of alcohol with cotton as a padding; or in a soldered box; or in a jar (the rubber of which must then be well covered with vaseline *to be afterward removed*); or simply wrapped in alcoholic cotton covered with paper and oiled silk or rubber sheeting, and packed in a box with soft material. Glass and metal packages are always boxed in wood.†

§ 54. **Embryonic fragments, and poorly preserved or** distorted specimens serve for preliminary dissections, so that the perfect material may be more completely utilized.

§ 55. **Every brain is numbered upon a list; and the** same number is affixed to it and to each part of it as soon as separated. **The numbers are written with India ink** upon bits of paper and attached by small (ribbon) pins.

§ 56. The list or catalogue gives the principal original data respecting the brain. Additional information, details of preparation, places of publication, points to be elucidated, etc., are recorded on slips the size of the U. S. postal card, filed in Manilla paper portfolios secured by an elastic band.‡

§ 57. Drawing the natural and dissected surfaces is insisted upon. These drawings should be, primarily at least, in outline only; shading, like charity, "covereth a multitude of sins."

§ 58. In beginning the study of a difficult region, the student is advised to determine at once some prominent feature as a landmark, as a "base," so to speak, of intellectual supplies, from which he may explore in any direction, and to which he may return when doubts arise.

§ 59. No observation involving either complex manipulation or novel results is published until it has been submitted to at least one other trained observer.

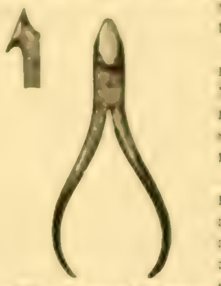


FIG. 4881.—Surgical [illegible] Bone Nippers. [illegible] tear the brain or its meninges.

§ 60. It is freely admitted that rarely, if ever, is all possible information gained from a specimen at one examination or by a single observer; hence specimens are preserved.*

§ 61. *Sawing.*—This (which might be called a macrotome) is a coverless box made of boards about 2.5 ctm. (1 inch) thick, and with the following inside dimensions: Length 30 ctm. (12 inches); height at middle, 25 ctm. (10 inches) sloping to 15 ctm. (6 inches) at the ends; width according to the length of the neck attached to the head, 25–40 ctm. All the parts must be accurately squared and put together with screws. The sides should go outside the bottom and ends and the bottom have a cleat at each end. Each side is to be divided at the middle of its length by a saw of the same thickness as that with **which the head is to be cut; the bottom** also is to be sawn to the depth of 1–2 mm. When finished the box should be thoroughly oiled inside and out with linseed or olive oil, to prevent warping when it is wet. For dividing the cranium any small saw will answer, but the edge should be rather wide so as to make a broad kerf. For medisection of the head, however, the saw should be very large, fine-toothed, narrow (*i.e.*, make a narrow kerf), have a removable back and be very sharp and free from rust.

§ 62. *Agate-ware Pans.*—The brain anatomist will find most convenient and in the end most economical one or two "nests" of iron pans "enamelled" so as not to rust, with plates of the same for covers. For the largest size (11 × 4) covers of glass or tin must be provided; these last will accommodate a half head.

§ 63. *Alcohol.*—Unless otherwise specified, the alcohol mentioned in this article is of the usual strength, ninety-five per cent. The admixture of alcohol with water in the following proportions gives various percentages: Alcohol 6, water 1 = 84 per cent.; 5 : 1 = 82; 4 : 1 = 78; 3 : 1 = 75; 2 : 1 = 67; 1.5 : 1 = 62; 1.25 : 1 = 60; 1.1 : 1 = 55; 1 : 1 = 48; 1 : 1.25 = 45; 1 : 1.5 = 42; 1 : 2 = 35; 1 : 3 = 30; 1 : 4 = 22; 1 : 5 = 18.4.

FIG. 4882.—Steel-bladed Spatula. × 0.5. (From catalogue of Whitall, Tatum & Co.) [illegible] when the calvaria is to be removed. § 66.

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* [illegible]

† [illegible]

‡ [illegible]

* [illegible]

* [illegible]

§ 64. *Alcoömeter (Alcoholometer).*—This form of hydrometer, for determining the percentage of alcohol in a given liquid, should be marked with Tralles' scale. With the slender jar for containing the tested liquid, the cost is about $2.50, but its employment is to be recommended upon the ground of ultimate saving of alcohol.

§ 65. *Circular Division of the Cranium.*—Reflect the scalp as directed in Vol. V., p. 789, or remove it altogether. Tie a cord around the head just dorsad of the ears, the frontal portion passing about 15 mm. from the brows; mark this line with a pen, or cut the periosteum to the bone. If the fresh calva is to be secured in place after the extraction of the brain, leave the fibrous cephalic and caudal margins of the temporal muscles for the stitches to be taken in; otherwise these muscles may be removed entirely.

In sawing,* three points are to be observed: (1) The thicker frontal and occipital regions should be taken first; (2) at four places, preferably what might be called the four corners of the cranium, the bone is not to be divided completely until the calva has been sagitally divided (§ 66); (3) if the ectal features of the brain are to be preserved intact, a medisected cranium should be consulted in order to estimate the thickness at various points, and frequent trials should be made by pushing a point, like the probe end of the tracer, into the kerf at the middle of that part of the convexity; when it can be pushed through, the sawing should proceed with care in each direction.†

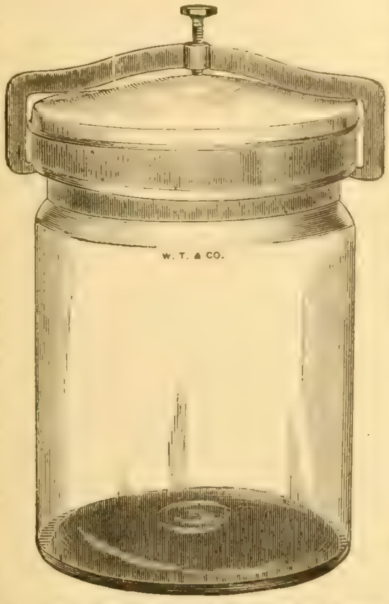

FIG. 4883.—Specimen Jar, with Glass Top, Rubber Ring, and Clamp. Made by Whitall, Tatum & Co., New York City. Fourteen sizes are made, ranging from 3 to 9 inches in diameter, and of various lengths. The size here shown is 6 × 8, and will receive a hemicerebrum or an entire half-brain; for undivided brains and for medisected heads the size 9 × 8 suffices. These two sizes cost, respectively, $10.00 and $18.00 per dozen. The prices given in the catalogue are subject to a discount of fifty per cent.

§ 66. *Sagittal Division of the Calva.*—After the circular kerf has been completed, but before the calva has been loosened by the chisel, carry a cord from the brows to the occiput, over the head, at about 13 mm. (half an inch) from the meson; along this line cut or mark the periosteum, and saw completely through the bone. Then, with taps of the hammer upon the chisel, sever the remaining attachments of the smaller part of the calva along the circular kerf. Sometimes that piece will come off readily; if not, introduce the spatula in the temporal region, where the bone is thin, keep its point pressed against the bone and so detach the piece; in some cases the spatula must be introduced at other points, always with the minimum amount of pressure upon the brain.

The mesal adhesions along the sinus are now directly accessible, and a sharp edge may be employed if necessary. The location of any other adhesions may commonly be inferred from what existed upon the first piece, and the operation is completed without difficulty.

If necessary, at once, or at any time, the two parts of the calva may be united by wires, or even cords, passed through holes at the middle and at each end; such holes may be made with a common awl of medium size, if a suitable drill is not at hand.

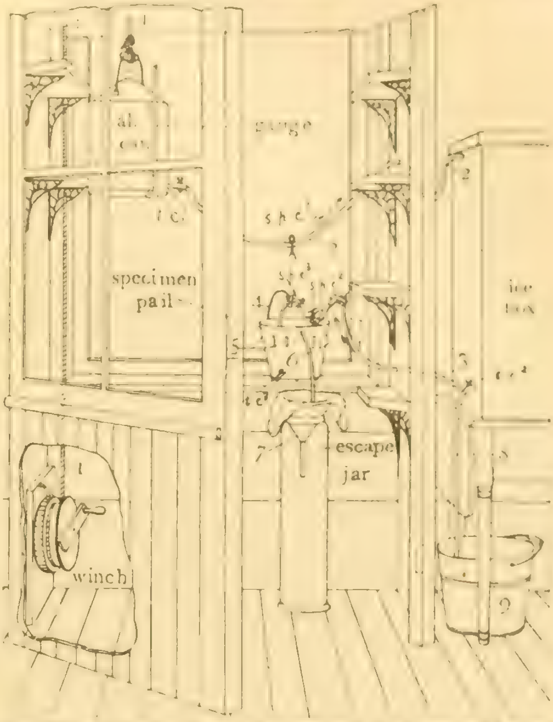

FIG. 4884.—Alinjection Closet and Apparatus in the Anatomical Laboratory of Cornell University; drawn from a photograph. 1, 1, 1, Successive parts of the cord supporting the alinjection can, passing up through a pulley (unseen), and down to the winch; 2, 2, parts of the tube leading to the "worm" in the ice-box (only half of which is shown); 3, 3, tube leading from the "worm" to the brain in the pail; 4, wire "crane" supporting that division of the tube, 3, which is connected with an artery; 5, socket, unoccupied, for a crane; 6, escape-tube; 7, tunnel for filtration in the escape jar; 8, waste pipe from the ice box; 9, waste-pail; *s. p. c.* ^{1}, ^{2}, ^{3}, screw pinch cocks controlling the flow in, respectively, the main tube, the artery tube, and the tube to the dura; *t. c.* ^{1}, ^{2}, ^{3}, turn-cocks at, respectively, the alinjection can, the ice box, and the specimen-pail. The closet door has been removed; the upper part is not shown, and part of the wall of the lower is represented as if cut out so as to expose the winch. The farther side is a window for light, and—in winter—cold. See § 22 for the consideration of temperature, and § 70 for certain details. The alinjection closet and apparatus here shown were constructed and employed under what may prove to be a misapprehension as to the necessity of maintaining a low temperature of the alcohol and the specimen during the operation. In warm weather the alcohol was conducted through a spiral coil and lead pipe within the ice box, and the specimen itself or the pail in which it was, was surrounded by ice or kept in a refrigerator perforated for the passage of the tubes. In winter the window was opened sufficiently to effect the purpose. Notwithstanding the present doubt respecting the advisability of maintaining a low temperature during alinjection, such a closet is a desirable adjunct to a laboratory for many purposes. The winch and pulley are convenient, but it is by no means certain that all necessary changes in the pressure might not be made by having two sets of shelves, side by side, alternating so that by moving from one to another the can might be raised or lowered for only half its height. The can itself is an ordinary five-gallon, tin oil can, with a cock, and, in addition, an L-shaped tin tube let in near the bottom for the insertion, with cement, of a glass tube graduated so as to indicate the litres contained at any time, and thus the amount that has passed to the brain. The cocks [illegible] and the tube still smaller, and connected with the cock by a tapering glass piece. The rubber tubes near the brain are [illegible] size made. A smaller can may, of course, be used. The [illegible] may be of wood, holes bored for turn-cocks, and the [illegible] porting the cannulas pushed into holes [illegible]

§ 67. *Removal of the Metencephal.*—After the removal of the cerebrum (§ 16) this is comparatively easy; the tentorium is divided at its periphery and lifted

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latter purpose are supplied by E. N. Cook & Co., of Buffalo, N. Y. For official information, see Section 3297, U. S. Rev. Statutes, Treasury Circulars of January 2, 1886, and March 26, 1889 (this last is comprehensive), and a ruling as to the use of untaxed alcohol in a hospital, New York Medical Journal, March 30, 1889, pp. 363, 364.

* Most of the sawing should be done by an assistant, that the chief may better accomplish the later operations.

† For the method of Féré, see *Bulletin de la Société Anatomique de Paris*, ii., 206, 207; for that of Spitzka, Journal of Nervous and Mental Disease, July, 1883.

carefully from the membranes, vessels being divided as they appear; the cranial nerves and the dura may be cut away more completely if necessary; by tilting the brain half one way or the other in the trough the nerves may be seen and divided, and the myel is finally cut as far down the spinal canal as possible. For some purposes, as when the ependyma is especially to be studied, the brain may be suspended in the preservative by a string tied about the myel, or about a pin passed through it from side to side; most securely, especially with infant brains, by retaining one or two vertebræ.

§ 68. *Hardening the Brain in Situ by Continuous Arterial Injection.*—The head should not be more than twenty-four hours old, and should have been kept cool, without freezing. Note the relations of the carotid and vertebral arteries on a preparation or model, or in Figs. 1190, 2441, 2448, 2449, 2441, 2444, and 2445, and in the article, Vessels of the Brain.

§ 69. *Clearing the Vessels.*—Inject normal salt solution (sodium chloride, 15 grams; water, 2 litres) into a vertebral and either carotid artery (preferably on the same side) until the liquid runs clear from the other arteries. Place in the aspirator can about five litres of twenty-two per cent. alcohol strained through absorbent cotton or filter-paper; raise the can to about one metre. In connecting the tubes let all air-bubbles escape. Small arteries that leak must be tied or secured with serres-fines (Fig. 2460). The liquid should escape in six to eight hours, and be quite bloody. If the last of it is nearly free from blood, the strong alcohol may be used; if not, repeat, using half the quantity of twenty-two per cent.

§ 70. The strong (ninety-five per cent.) alcohol may now be used at the same pressure; it will pass through at a rate varying from one-third to eight-tenths of a litre per hour, and be reduced to seventy-five or eighty per cent. At the end of the third day, and perhaps earlier, the strength of the alcohol will be but little reduced; the pressure may then be lessened by lowering the can to one-half the height. By the sixth day the loss in strength may be no more than three per cent., and the discoloration insignificant. The injection may then be discontinued, and the head sawed (§ 71) or otherwise prepared. If desired, a colored injection mass may be thrown into the arteries of either the face (external carotids) or the brain (internal carotids and vertebrals), or of all.

§ 71. *Marking of the Head.**—Determine the plane of section by the following mesal points, some of which, of course, are subject to variation: (1) Interval between the central incisors in each jaw; (2) dimple at tip of nose; (3) occipital protuberance (inion); (4) nasal; (5) vertebral ventrum; (6) notch in cephalic margin of larynx; (7) dimple of chin; (8) middle of top of head. This last is ascertained by carrying a piece of inelastic cord over the top of the head, securing each end in an auditory meatus by crowding cotton in with it, and then finding the middle of the cord. At each mesal point make a short but deep incision. Knot one end of a cord long enough to surround the head and neck at the meson; place the knot mesad of the central, maxillary (upper) incisors, carry over the nose, head, neck, and chin back to the mandibular incisors, between which it may be secured by a wedge or otherwise. With the [illegible] divide the scalp, etc., along one side of the cord. Remove the cord, and at the occipital convexity (about at the site from 3 in Fig. 2884) bore a hole at the meson deep enough to permit a screw to be firmly fixed.

§ 72. *Adjusting the Head.*—Place the head in the saw-box and mark with a pencil the points where the bottom and one side are in contact with the occipital region and the vertex; at these points bore a hole in the kerf large enough to admit one of the screws. Replace the head in as nearly as possible the same position; pass the spatula through the kerf above the hole in the side opposite the vertex, and adjust the head so that the end of the spatula is in the cut in the scalp. While steadied in that position pass the gimlet or awl through the hole and bore into the skull for a short distance, 3 to 5 mm.; insert the screw at that point. Repeat the operation for the occipital region; this screw should bring the head firmly against the bottom of the box; if it is necessary or desirable to remove the head in order to bore the holes, when the head is replaced the holes may be found by means of the probe-end of the tracer.

§ 73. *Packing.*—Draw through the kerfs in the two sides a cord just large enough to fit tightly, and pull it down so that it coincides with the cut in the skin of the face. Pack the cotton first in the angle between the two screws, then under the neck, keeping the whole constantly adjusted by means of the thread and the kerf at the near side of the box. When firmly packed, pour over the cotton some water until no more is absorbed.

§ 74. *Sawing.*—Remove the cord from the kerf; insert the saw so that the handle is close to the side of the box, and make the first few strokes by drawing only; then saw in the usual way; a fine stream of alcohol (fifty per cent. alcohol forty-eight) should irrigate the blade during the entire operation. The back of the saw should be retained as long as possible, and screws not removed until nearly reached by the saw. Let a gentle stream of water flow over the sawn surfaces and place at once in alcohol.

§ 75. *Removal of the Hardened Hemicerebrum.**—Remove the falx and [illegible] tentorium. At the base divide the infundibulum close to the [illegible], leaving the hypophysis to be removed separately. Note the location of the optic nerve, and divide by carrying the scalpel point latero-cephalad from the infundibulum for 1 to 2 cm. close to the dura, lest the olfactory area be injured. Dislodge the olfactory bulb with the [illegible], turn it just over the margin of the hemicerebrum, and secure it by a small pin at either side.

§ 76. *Transection of the Hemicerebrum.*—Recognize, if possible, the dorsal end of the central fissure, nearly dorsad of the splenium. Place a strip of paper or a card across the hemicerebrum, between points about 5 mm. caudad of the fissure and the splenium. The half-head should be in alcohol or the cords should be flooded. The vertex should be toward the operator. Note on the empty half head the angle formed by the tentorium with the meson, or observe on the preparation at hand. Pass the scalpel into the brain close to the tentorium, and with a gentle sawing movement carry its point as far as it will go; continue the movements dorsad, making sure that the broad edge of the half of the scalpel does not bruise the brain. The completion of the transection is announced by the loosening of the occipital region. Probably the greatest difficulty will be the division of the extreme ventral part. To remove the occipital part push the probe-end of the tracer or a very narrow-bladed scalpel (Fig. 2880) into the brain 10–12 mm. caudad of the section plane, near the tentorium and between two fissures; the direction should be dorso-lateral at an angle of 45 degrees, thus nearly perpendicular to the cut surface of the cranium toward which it is pointing. Dislodge the tip of the occipital lobe by coaxing with the scalpel handle; lift the whole piece slightly with the inserted instrument; it will come out for a certain distance and then be checked by veins which may be divided with scissors.

§ 77. *Mesencephalic Transection.*—From Figs. 4724 and

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* The following instruments and apparatus should be provided (see § 67): [illegible]

* The following instruments and materials should be provided: [illegible]

4728 note that (1) the crusta projects considerably ventrad of the mesal cut-surface and (2) that the greatest width of the crus is not more than 15 mm. Hold the scalpel with the flat side at an angle of about thirty degrees with the meson, let the ink-mark be at the ventral margin of the crus, and cut dorsad with sawing strokes. Place the specimen so that the depths of the incision are illuminated, and divide whatever may appear; the hemicerebrum will float up, and be readily removed if the dorsal margin be first disengaged and the prominence of the temporal lobe kept in mind.

§ 78. *Removal of the Metepencephal.*—If the tentorium is to be retained, divide it by cutting laterad from a point just caudad of the angle between the natural, curved margin and the cut, straight margin; it is more convenient to remove it entirely. The half-head may now be placed upon a tray and supported, or held by an assistant. Crowd the edge of the round scalpel-handle between the dura and the myel for 2–3 mm., beginning at whatever point a slight interval already exists, and continue the separation by gentle, yet firm pressure; special difficulties will be encountered at and near the occipital foramen, requiring perhaps the scalpel-edge. Do the same for the cerebellum and pons, keeping in mind the natural curvatures of the surfaces and the locations of the larger nerves, especially the trigeminus and the auditory and facial. Specific directions are hardly possible for the rest of the operation.

§ 79. *Arterial Alinjection of a Brain in the Dura.*—The vessels must first be washed out (§ 69), and the small arteries tied or secured with *serres-fines* (Fig. 1736).

§ 80. *Entocœlian Alinjection per Luram.*—Four points are to be kept in mind: 1, The smallness of the orifice (Fig. 4689), which may be enlarged if desired with the probe or by clipping the infundibulum shorter; 2, the general dorso-caudal direction of the passage (Fig. 4711); 3, the danger of wounding the parietes, and especially the medicommissure: the cannula should therefore be short, the tube small and flexible, and the cannula pushed through a disk of rubber so as not to enter more than 1 ctm.; 4, the weakness of the encephalic substance after death: hence no more pressure should be exerted than suffices to fill the cavities and cause a slight elevation of the tips of the temporal lobes; the alinjection-can should be just above the level of the brain, and the cannula fit loosely in the lura so that the excess of alcohol may escape.

§ 81. *Combined Arterial and Entocœlian Alinjection.*—This very effectual method of preserving a brain removed in the dura for any macroscopic purpose was employed with the specimens shown in Figs. 4740, 4742, and 4833. A separate reservoir must be used for the entocœlian alcohol (§ 80), or the branch-tube leading to the lura must be small and kept compressed so that—when the cavities are once filled—the flow will be very slight.

Burt G. Wilder.

BRAIN, SURGERY OF THE. [Cerebral surgery is so new, and its progress so rapid, that the opinions here expressed must be considered as only tentative, and as only representing my opinions at the time of writing it (December, 1888). It may possibly be the case that, even when it is published, a larger experience will have very materially modified my views on a number of points.]

History.—Although in 1871 Broca located a cerebral abscess in the speech centre, and greatly relieved the patient by trephining, modern Brain Surgery begins properly with a modest report of a case by Macewen in the *Glasgow Medical Journal* for 1879, xii., 210, and a later more elaborate paper, by the same author, in *The Lancet* for 1881, ii., p. 541. In these papers he narrates three cases occurring in 1876 and 1879, in which cerebral disease was located by focal symptoms. The first was a case of convulsions of the face, arm, and leg, in the order named, following a fall on the right side of the head. A trephine opening of the dura evacuated two oz. of blood, and the boy recovered without any febrile movement.

In the second case the symptoms pointed to a lesion of the frontal lobe, and, after trephining, a tumor of the dura mater was dissected out. The patient died eight years subsequently, from Bright's disease.

The third was a case of cerebral abscess existing, not at the site of a prior injury marked by a distinct cicatrix, but correctly diagnosticated in a totally distinct position, that is, in Broca's convolution, by the focal symptoms. The parents declined an operation, and the child died. After death an operation was done precisely as it would have been done during life, and an abscess was found the size of a pigeon's egg at the spot indicated by the localizing symptoms.

In spite, however, of this remarkable paper, the surgical world seemed blind to its opportunity. But in *The Lancet* for December 20, 1884, Dr. Hughes Bennett and Mr. Godlee narrated a case of subcortical tumor of the brain, diagnosticated by the localizing symptoms alone and before operation. When the dura was opened no tumor was visible; but so certain were they that a tumor existed, that an incision was made in the apparently healthy brain tissue, and a morbid growth the size of a walnut was found one fourth of an inch below the surface. This case, though ultimately unsuccessful because of suppurative meningitis, instantly arrested the attention of the surgical world by the precision of the diagnosis, the success of the operative technique, and the evidence it afforded that we could successfully cope with heretofore hopeless cases. Its very failure, like the failure of the first Atlantic cable, but pointed the way to success.

The first American paper on cerebral tumor, by Hirschfelder and Morse, of San Francisco, appeared in the *Pacific Medical and Surgical Journal* for April, 1886. The case was that of the successful localization, but unsuccessful removal, of a brain tumor.

Two most remarkable papers on brain surgery, however, were published soon afterward by Mr. Victor Horsley, in the *British Medical Journal* for October 9, 1886, and April 23, 1887. In these papers ten cases were related, all of which were correctly localized; only one died, and the remainder were either benefited or cured. These were cases of removal of brain tumor, and even of portions of diseased brain-tissue, the cause of epilepsy, intense headache, etc. Since then a large number of papers have appeared, and among them one in the *British Medical Journal* for August 11, 1888, by Mr. Macewen again, which has but confirmed the sanguine expectations created by his brilliant paper of 1881. I shall refer in the course of this paper to a number of other publications, but I have thought it right to sketch thus briefly the historical development of the subject.

In this country, besides many excellent publications that I have not space or time to enumerate, the most noteworthy papers published have been those by John B. Roberts, read before the American Surgical Association in 1885; two by R. W. Amidon, in the *Medical News* for January 21, 1884, and the *Annals of Surgery*, vol. i., 1885, both of these authors putting forth strong pleas for more heroic surgical interference in affections of the brain; and one by Seguin and Weir, in the *American Journal of the Medical Sciences* for July, August, and September, 1888. I have also published two papers to which I may allude, one in the *American Journal of the Medical Sciences* for October and November, 1888, and another in the *Medical News* for December 1, 1888. In Germany perhaps the most elaborate and important paper is that by v. Bergmann, in *Langenbeck's Archiv*, Bd. xxxvi., Heft 4.

In addition to these, Mr. Horsley has published, in the *British Medical Journal* for June 16, 1888, an account of the removal of a tumor from the spinal cord, and Mr. Macewen, in his paper last referred to, published six cases in which the posterior arches of the vertebræ had been removed for tumor and compression of the cord, and for an abscess in the posterior mediastinum, two of which (paraplegia from Pott's disease and fractured spine) had been published as early as 1886 (*Glasgow Medical Journal*, xxv., 210). (See article on Surgery of Spinal Cord, farther on.)

Two things have made such brain surgery possible. First: the accurate localization of the functions (especially the motor centres) by Ferrier, Horsley, Fritsch,

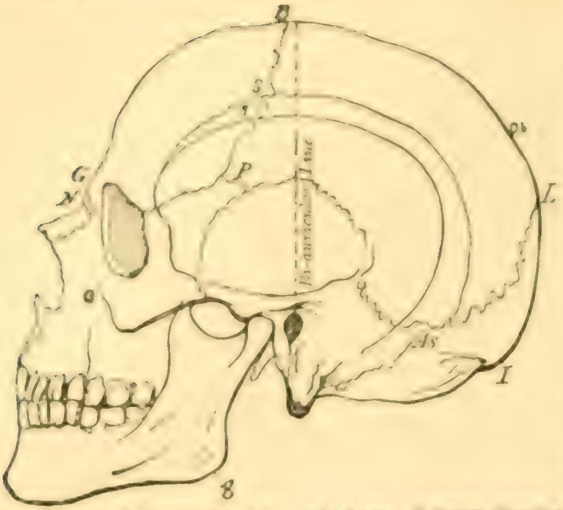

Fig. [illegible].—Skull showing Points named by Broca. N, Nasion [illegible]

Hitzig, and others) by means of which we can with fair accuracy determine the site of a tumor, abscess, cyst, etc., by the focal symptoms. Secondly, the impunity with which we can trephine and **open the dura mater, and interfere with the** brain-tissue itself, is due almost entirely to the introduction of antiseptic surgery. To Horsley more than to anyone else we owe the formulation of rules for successful brain surgery, rules which will be given at length hereafter.

The Danger of Trephining.—For the technique of trephining I refer the reader to the paper under that head by Dr. Park in Vol. VII. of this HANDBOOK. But it is important further to consider the question of the danger involved in this operation. In St. Bartholomew's Hospital Reports for 1882 Dr. Walsham published a paper entitled "Is Trephining of the Skull a Dangerous Operation per se?" In this article he analyzes 686 cases, of which 417 survived, the mortality, therefore, being 39.2 per cent. Dividing these large numbers into classes: first, those in which preventive trephining was used (mostly all for fractures), there being no cerebral symptoms, the mortality was 21.9 per cent. Second, trephining in which severe cerebral symptoms existed, the mortality was 48.4 per cent. Third, trephining in which moderate cerebral symptoms were present, the mortality was twenty-seven per cent. Fourth, late trephining, mostly after inflammation had set in, the mortality was 58.6 per cent. Fifth, late or secondary trephining showed a mortality of twenty-two per cent.

Walsham showed that in 172 cases of late trephining in which there was no condition endangering life, only 10.6 per cent. died. Amidon, in the paper referred to, analyzes 100 cases of trephining reported since 1879, in most of which antiseptics were employed. Of these 100 cases 26 died, but of these 23 presented at the time of operation symptoms already endangering life. He therefore concluded, and most later writers practically concur in his conclusions, that the mortality of trephining per se is but three per cent., a conclusion which would seem to be confirmed by Prunières and Robert Fletcher, by their investigations, which show the frequency of recovery in cases of prehistoric trephining. Seydel ("Antiseptic und Trepanation") even estimates the mortality as only 1.6 per cent.

Not only have antiseptics thus diminished the danger of simply opening the cranium, but the numerous cases which have been reported of opening the dura, followed by removal of tumor and also of more or less brain-substance, clearly show that but little danger is added in any case by such novel surgical procedures. "Heretofore," says Amidon, "the boldness of the surgeon to open the cranium seems audacity as compared with his hesitation in piercing the dura mater. The cerebral cortex seems to be a 'dead line' inside the prison walls of conservative surgery, across which even the most daring are tempted, or the most unwilling are dragged, only by sure indications or desperate chances."

The future danger seems to be, however, that temerity may take the place of timidity, and that many patients will either die or go about with mutilated brains that ought never to have been touched. This word of caution, therefore, at the outset may not be out of place.

TOPOGRAPHY OF THE BRAIN IN ITS SURGICAL RELATIONS.—The relation of the chief fissures and convolutions of the brain to the surface of the skull has assumed of late the greatest possible importance. It is essential that we shall be able, from fixed landmarks on the skull, to locate the various fissures and convolutions, and by them the various cortical centres. The subject has recently been studied by Reid,[1] Horsley,[2] and Hare,[3] each of whose methods of research has its own merit.

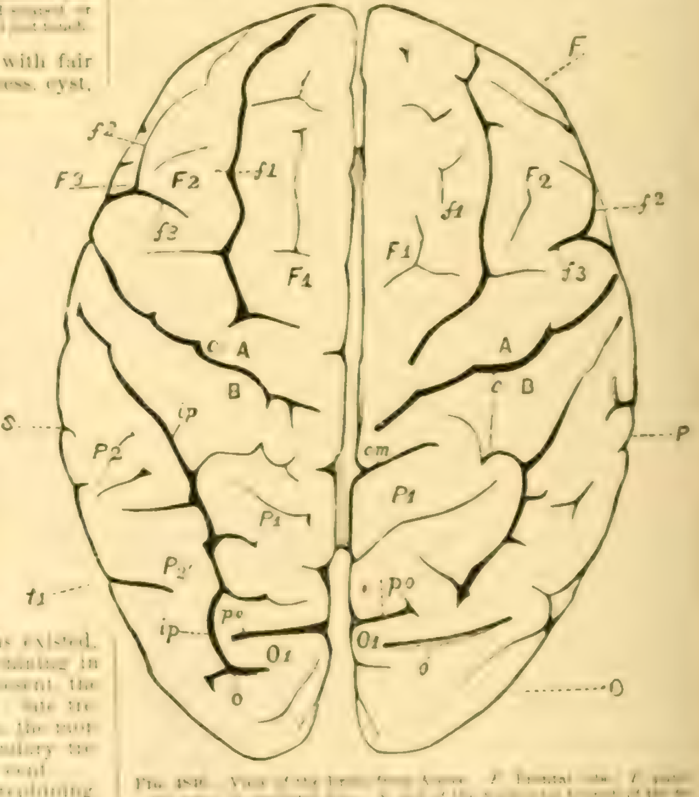

Fig. [illegible].—View of the Brain from Above. F, frontal lobe; f, [illegible]

I shall give a brief outline of the three methods, and in doing so, I must take it for granted that the reader is fairly well acquainted with the chief outlines of the cerebral cortex. In order, however, to facilitate the study of the external topography of the brain, I have introduced cuts.

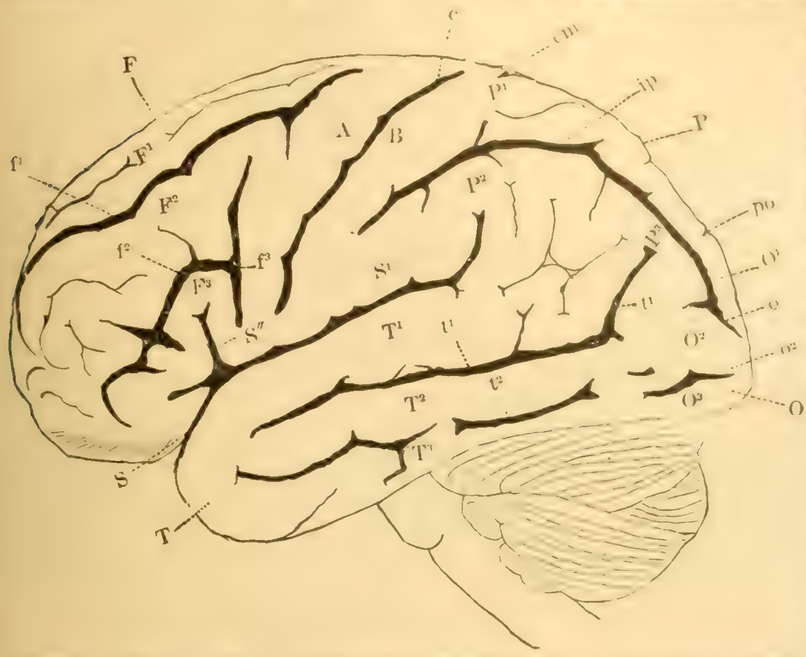

Fig. 4847.—Outer Surface of the Left Hemisphere. F, Frontal lobe; P, parietal lobe; O, occipital lobe; T, temporo-sphenoidal lobe; S, fissure of Sylvius; S', horizontal, S'', ascending ramus of the same; c, central sulcus or fissure of Rolando; A, anterior central or ascending frontal convolution; B, posterior central, or ascending parietal convolution; F^1, superior, F^2, middle, and F^3, inferior frontal convolutions; f^1, superior, f^2, inferior frontal sulcus; f^3, præcentral sulcus; P^1, superior parietal or postero-parietal lobule; P^2, P^3, inferior parietal lobule, viz.: P^2, supra-marginal gyrus; P^3, angular gyrus; ip, intraparietal sulcus; cm, termination of the calloso-marginal fissure; O^1, first, O^2, second, O^3, third occipital convolutions; po, parieto-occipital fissure; o^1, transverse occipital sulcus; o^2, inferior longitudinal occipital sulcus; T^1, first, T^2, second, T^3, third temporo-sphenoidal convolutions; t^1, first, t^2, second temporo-sphenoidal sulci. (Ecker.)

First: Fig. 4845, from Broca, giving the points named upon the skull.

Secondly: Figs. 4846–4848, from Ecker, giving the names of the principal sulci and convolutions.

I have also appended two figures from Ferrier's "Functions of the Brain" (Figs. 4849 and 4850) in order to fix as nearly as possible the relations of the various centres, so far as known at present. The figures in these two cuts are placed as follows:

(1), On the postero-parietal lobule (precuneus), the centres for movements of the opposite leg and foot in locomotion. (2), (3), (4), At the upper end of the fissure of Rolando, and hinder part of the first frontal convolution, the centres for various complex movements of the arms and legs, as in climbing, swimming, etc. In this area Horsley states that the arm and leg of the same side are involved together. (5), At the posterior part of the superior frontal convolution—extension forward of the arm and hand, as in putting forth the hand to touch something in front. (6), On the ascending frontal [pre-Rolandic] convolution, just behind the upper and hinder end of the middle frontal convolution—movements of the hand and forearm in which the biceps is particularly engaged, viz., supination of the hand and flexion of the forearm. (7) and (8), Respectively for the elevators and depressors of the angle of the mouth. (9) and (10), As one mark the centre for movements of the lips and tongue, as in speech. This especially occupies the posterior portion of the inferior frontal (generally known as Broca's) convolution. Disease of this region on the left side produces aphasia. (11), The centre for the platysma, retraction of the angle of the mouth. (12), A centre for the lateral movements of the head and eyes, with elevation of the eyelids and dilatation of the pupils. (13) and (13'), On the supra-marginal lobule and angular gyrus, including also the occipital lobe, indicate the centre for vision. (14), On the superior temporo-sphenoidal convolution, indicates the centre for hearing. (*a*), (*b*), (*c*), (*d*), On the ascending parietal [post-Rolandic] convolution, indicate the centres for movements of the fingers and wrist. The centre for smell is situated in the hook of the hippocampal region (Fig. 4848, *U*). In close proximity, but not exactly defined as to limits, is the centre for taste. The centre for touch is situated in the hippocampal region (Fig. 4848, *H*) and gyrus fornicatus (*Gf*).

To this I also add Figs. 4851 to 4859 from Horsley's article (*Amer. Jour. of the Med. Sciences*, April, 1887) for the same purpose. I also add a figure from Gowers (Fig. 4860) to show the relations of the convolutions to the skull.

The reader desirous of further information will find

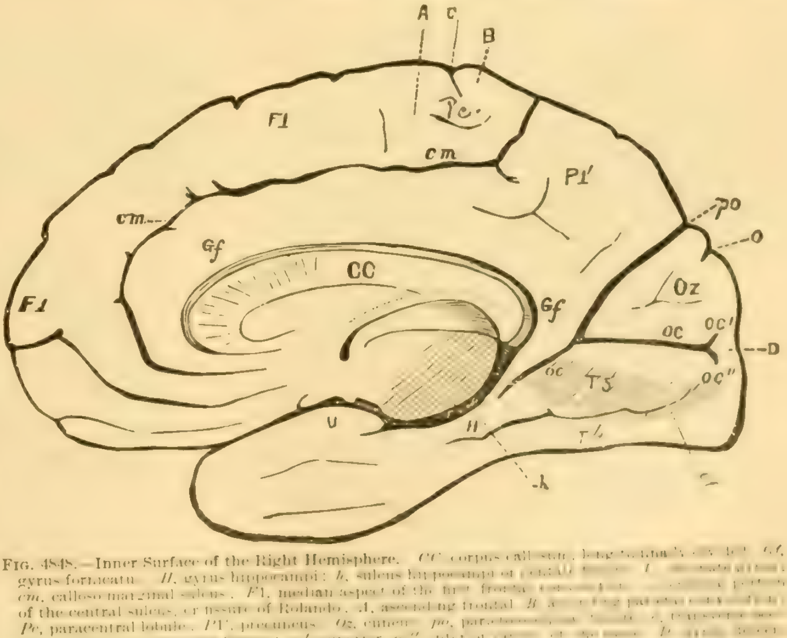

Fig. 4848.—Inner Surface of the Right Hemisphere. *CC*, corpus callosum, longitudinally divided; *Gf*, gyrus fornicatus; *H*, gyrus hippocampi; *h*, sulcus hippocampi or [illegible]; *U*, [illegible]; *cm*, calloso-marginal sulcus; *F1*, median aspect of the first frontal [illegible]; *c*, [illegible] of the central sulcus, or fissure of Rolando; *A*, ascending frontal; *B*, ascending parietal [illegible]; *Pc*, paracentral lobule; *P1'*, precuneus; *Oz*, cuneus; *po*, parieto-occipital [illegible]; *o*, [illegible] occipital sulcus; *oc*, calcarine fissure; *oc'*, superior, *oc''*, inferior [illegible]; *D*, gyrus descendens; *T4*, gyrus occipito-temporalis lateralis (lobulus fusiformis); *T5*, gyrus occipito-temporalis medialis (lobulus lingualis); *ct*, collateral or occipito-temporal fissure. (Ecker.)

is briefly stated in the last American edition of "Gray's Anatomy," pp. 881 et seq., as very fully in the works already referred to, together with Ferrier's "Functions of the Brain" (see also article "Skull, etc.," in Vol. VI.).

It must be borne in mind that, as pointed out by Stokes,* the relations between the brain and the skull vary at different ages, a fact reinforced by Cunningham's models of the brain hardened in situ, and then exposed by removing the bones of the skull, leaving bridges at the sutures. Symington* points out that the Sylvian fissure lies much higher above the squamo-parietal suture in the child than in the adult, and is from half an inch to even an inch above it. He thinks that they attain their adult relations at about the eighth or ninth year.

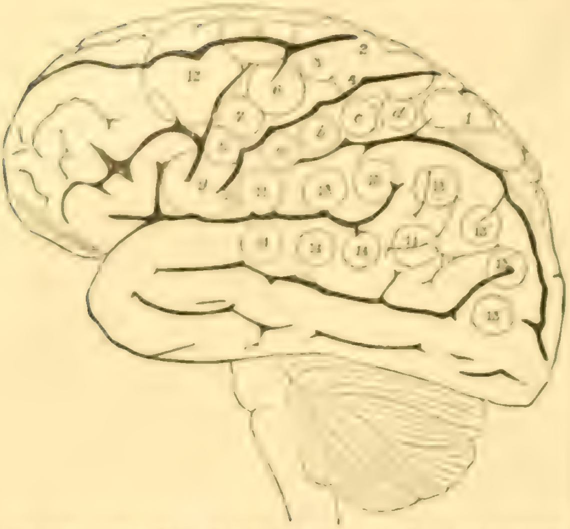

Fig. 4849.—Side View of the Brain of Man. (Ferrier.) (For references see p. 203.)

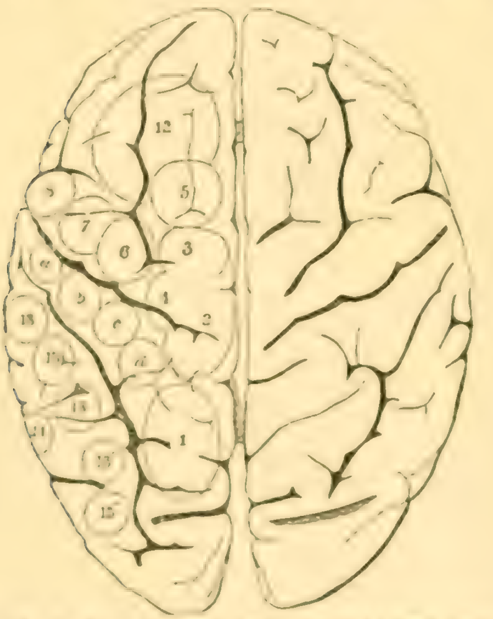

Fig. 4850.—Top View of the Brain of Man. (Ferrier.) (For references see p. 203.)

The fissure of Rolando is also much more oblique in its direction (52°, Hare) in the child, and lies farther forward on account of the imperfect development of the frontal lobes. Gradually as these are developed, especially the third frontal convolution, the lower end of the fissure is pushed back and it assumes its adult angle and position.

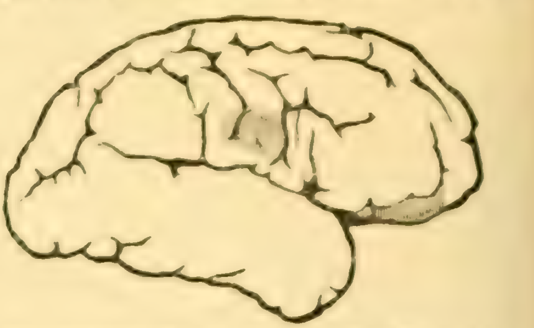

Fig. 4851.—Representation of the Centre for the Upper Face and Angle of the Mouth. (Horsley.)

First. *Landmarks on the Skull.* Most of these are readily determined by reference to the foregoing figures, but there are some which must be more minutely described.

The temporal ridges (Fig. 4845) are two in number: the upper for the temporal fascia, the lower for the upper border of the temporal muscle. The upper is the better marked and can be easily followed by the finger from the external angular process backward. It marks the sudden change in the slope of the skull, from the curve of the upper surface to the more vertical direction of the side. The lower one is best made out by closing and relaxing the jaw, when the upper edge of the temporal muscle can be located by the finger. Like the upper it begins at the external angular process, but runs at a lower level than the fascial ridge. Its middle is about two-fifths of an inch below it. The points where the coronal suture crosses these two ridges are called respectively the upper and lower stephanions (Fig. 4845, S and S').

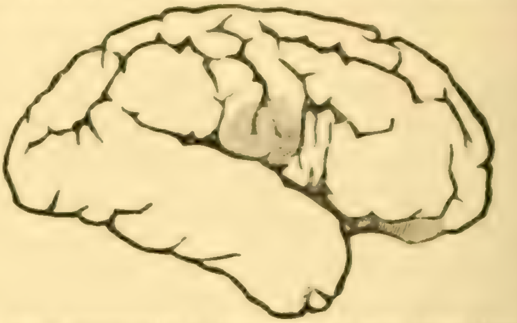

Fig. 4852.—Representation of the Centre for the Vocal Chords (Adduction). (Horsley.)

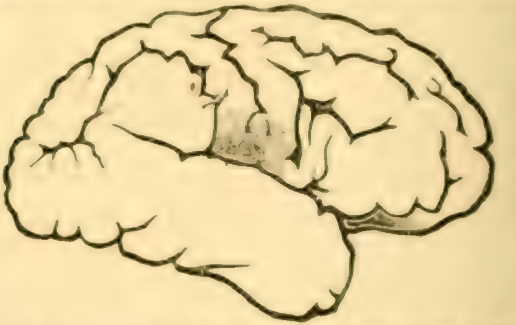

Fig. 4853.—Representation of the Centre for the Lower Face and Floor of the Mouth. (Horsley.)

The *coronal suture* starts at the bregma (Fig. 4845, *B*).

Drawing the bi-auricular line (Fig. 4845), measurements on 185 skulls have given me as a mean result, that in the adult the *bregma* lies 0.375 of an inch in front of this line. The greatest distance was 1.2 inch. In 16 of these skulls, the bregma coincided with the point where the bi-auricular line crosses the sagittal suture. In only 7 did it lie behind it, the maximum being 0.9 inch. Starting from the bregma, by shoving the scalp backward and forward, the finger can perceive (but with some difficulty, especially in the aged) the irregularities of the coronal suture, but toward the stephanion they become more marked and can be pretty well appreciated. The *parieto-squamosal* suture lies beneath the temporal muscle. The highest point of its curved line is at the junction of the upper and middle thirds of a vertical line drawn from the upper border of the zygoma to the ridge for the temporal muscle in front of the temporo-maxillary articulation.

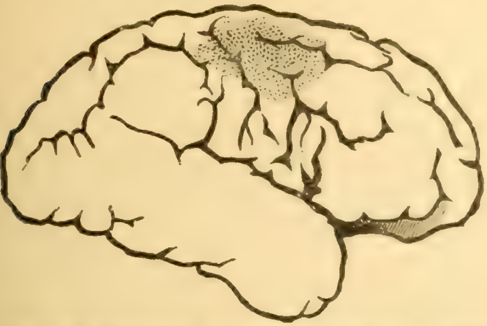

FIG. 4854.—Representation of the Centre for the Shoulder. (Horsley.)

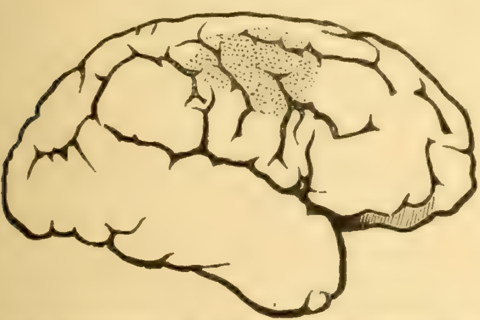

FIG. 4855.—Representation of the Centre for the Elbow and Wrist. (Horsley.)

The point of junction of the great wing of the sphenoid, frontal, parietal, and squamous bones is called the *pterion* (Fig. 4845), and is about half-way between the superior stephanion and the zygoma. It is usually H-shaped.

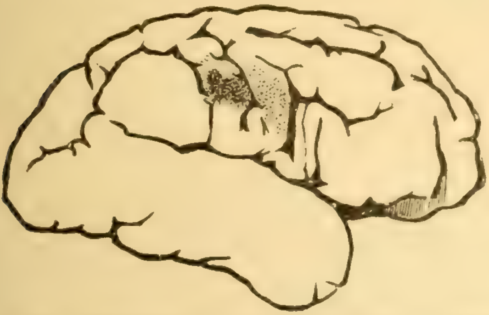

FIG. 4856.—Representation of the Centre for the Thumb. (Horsley.)

The Relation of the Fissures and Convolutions to the Landmarks on the Skull.—There are five great fissures of the brain to be localized.

First. The *great longitudinal fissure* separates the two hemispheres of the cerebrum. This does not lie precisely in the middle line, but in consequence of the slightly larger size of the left hemisphere, it lies about an eighth of an inch to the right of the middle line.

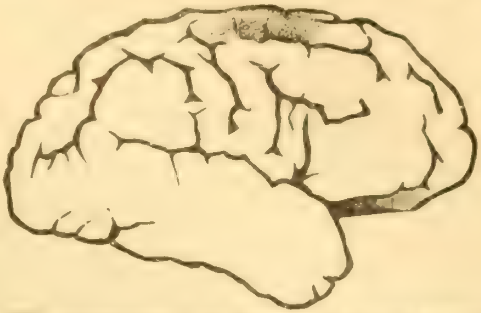

FIG. 4857.—Representation of the Centre for the Combined Synergic Action of Both Limbs. (Horsley.)

Second. The *great transverse fissure*, or the fissure of Bichat, between the cerebrum and the cerebellum. This lies in a line from the external auditory meatus to the *inion* (or external occipital protuberance). This marks also the position of the tentorium and of the lateral sinuses. The other three great fissures (viz., the *fissure of Sylvius*, the *fissure of Rolando*, and the *parieto-occipital fissure*) will be given under the following rules.

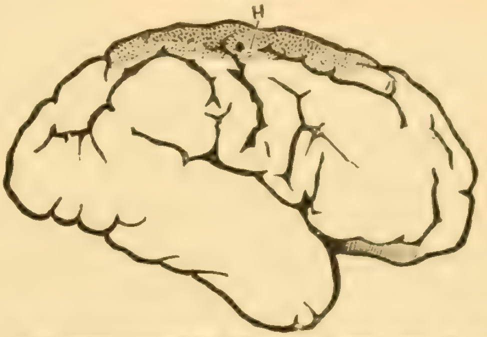

FIG. 4858.—Representation of the Centre for the Lower Limb. H, Focus of representation of the Hallux. (Beevor and Horsley.)

Horsley's Method.—The *fissure of Rolando*, in relation to the motor region, is the most important in the whole brain. As will be seen by reference to Figs. 4849 and 4850, almost all the motor centres lie clustered about it. As Thane has shown, it runs downward and forward from

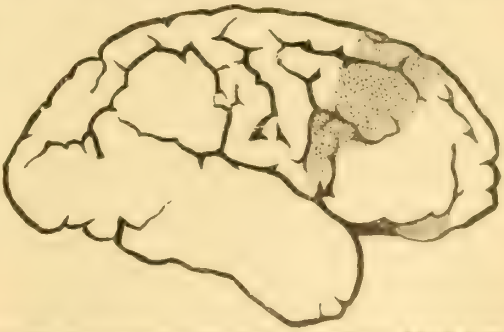

FIG. 4859.—Representation of the Centre for the Head and Neck, together with Conjugate Deviation of the Eyes. (Horsley.)

a point half an inch behind the middle of the distance from the glabella to the inion. This point being fixed, if a line be drawn forward at an angle of 67° (as shown by Hare) for a distance of 3¾ inches, it will indicate the fissure of Rolando, the lower third of the fissure, however, changes to a somewhat more vertical direction, thus forming a knee-like bend. To fix this important fissure Horsley uses a strip of metal or of parchment paper, say

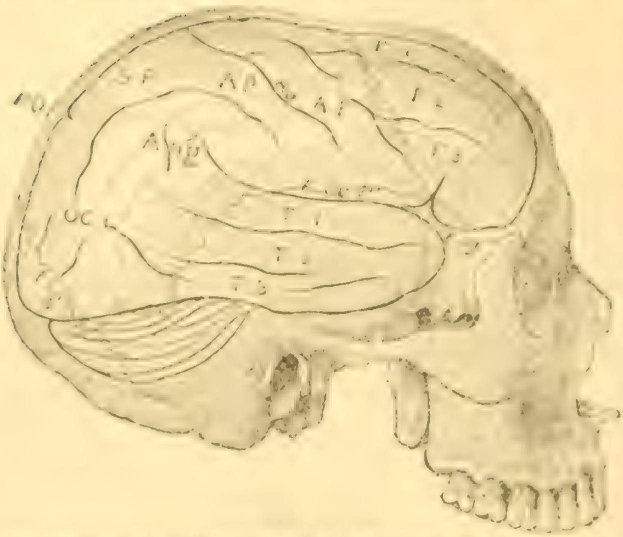

FIG. 4860.—Diagram of the Relations of the Convolutions to the Skull. F 1, 2 and 3, Upper, middle, and lower frontal convolutions; A F, A P, ascending frontal and parietal convolutions; S P, sup. parietal lobule; A g, angular gyrus; O C, occipital lobe; T 1, 2, 3, the temporo-sphenoidal convolutions; P O F, parieto-occipital fissure; F Sy and F Sy P, fissure of Sylvius and its posterior limb. (Horsley.)

fourteen inches long, with a second strip firmly fixed to it at an angle of 67° (Fig. 4861).

The zero point of the scale of the longer piece (as suggested by Dr. Morris J. Lewis of Philadelphia) is placed half an inch in front of the angle formed by the two arms. From this zero point the scale (in quarter inches) reads both forward and backward. The longer arm is placed in the middle line of the shaven head in such a position that the readings of the two scales at the glabella and at the inion shall be identical. The lateral strip will then mark the fissure of Rolando (3¾ inches), the direction of the lower third being slightly changed, as above indicated.

The *fissure of Sylvius* commences at the pterion, the anterior branch running upward and forward, continuing the line of the squamo-sphenoidal suture, but one or two millimetres in front of it. The posterior branch passes upward and backward half a millimetre above the squamo-parietal suture, as far as its highest point, and from there curves slightly upward toward the centre of the parietal eminence, which it nearly reaches. This fissure limits the motor region anteriorly by its anterior limb, and postero-inferiorly by its posterior limb.

The *precentral or vertical sulcus* is of great importance also, as it divides two convolutions of very different functions, and on each side of it has convolutions of great motor importance. It runs parallel to and just behind the coronal suture, and is almost vertical to a horizontal tangent at the bregma (hence its second name). Its upper end reaches to the level of the middle of the fissure of Rolando. From it, about on a level with the superior [illegible], the *superior frontal sulcus* runs forward. Above the origin of this latter sulcus, the precentral sulcus continues vertically half-way across the root of the middle frontal convolution. Its lower end is separated from the fissure of Sylvius by a horseshoe-shaped convolution of great importance (the *operculum*), which is nearly always one centimetre wide, and overlies the island of Reil.

The *superior frontal sulcus* starts from the ascending frontal [pre-Rolandic] convolution midway between the fissure of Rolando and the line of the precentral sulcus. Its posterior end, therefore, lies behind the precentral sulcus. The *superior* and *inferior frontal sulci* run forward and slightly downward, practically parallel with the great longitudinal fissure.

The *intra-parietal sulcus* lies behind the fissure of Rolando and bounds the motor area posteriorly. It begins opposite the knee-like bend at the junction of the middle and lower thirds of the fissure of Rolando. As it goes upward it lies about midway between the line of the Rolandic fissure and the parietal eminence. It then separates farther from the fissure of Rolando and so widens the area of the ascending parietal [post-Rolandic] convolution, that its upper end is known as the *superior parietal lobule*. In the middle of its course it runs about parallel to the great longitudinal fissure, and midway between it and the parietal eminence. Further on it passes by the external end of the parieto-occipital fissure, and goes downward and backward into the occipital lobe.

The *parieto-occipital fissure* on the upper surface of the cerebrum is a short fissure about an inch long, at right angles with the great longitudinal fissure, and two or three inches in front of the *lambda* (the junction of the lambdoidal and sagittal sutures) (Fig. 4845, *h*). This fissure, on the median surface of the cerebrum (Fig. 4848, *po*), is a long fissure running downward and forward. It is joined at its middle by the *calcarine fissure* (Fig. 4848, *ca*). Between these two fissures is the *cuneus* (*Cu*, Fig. 4848), in which lies the centre for sight. Injury to the cuneus, therefore, produces blindness in the half of each retina on the side corresponding to the injury.

In front of the parieto-occipital fissure, on the middle surface of the hemisphere, lies the *præcuneus* or *quadrate lobule* (Fig. 4848, P), bounded in front by the upper end of the *calloso-marginal fissure* (*cm*).

In front of and behind the fissure of Rolando (Figs. 4846 and 4847) are two most important convolutions. The one in front is chiefly known as the ascending frontal or precentral or, as I prefer to term it, the *pre-Rolandic convolution*. The one behind the fissure of Rolando is known as the ascending parietal or postcentral, or, as I prefer to term it, the *post-Rolandic convolution*. At their upper ends they fuse into the *paracentral lobule*, and at their lower into the *operculum*. The two frontal sulci divide the frontal lobe horizontally into three convolutions, viz., the first, second, and third, or respectively the *superior*, *middle*, and *inferior frontal convolutions*. The third or inferior convolution is frequently known as *Broca's convolution*. On the left side the *centre for speech* is located (in left-handed persons this speech centre lies in Broca's convolution on the right side). For the location of other centres in these various convolutions the reader is referred to Figs. 607, 617, 4846, 4847, and 4848.

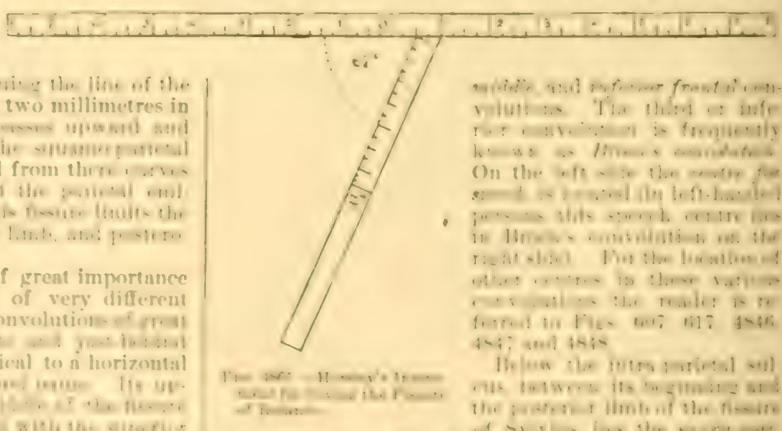

FIG. 4861.—Horsley's Instrument for Finding the Fissure of Rolando.

Below the intra-parietal sulcus, between its beginning and the posterior limb of the fissure of Sylvius, lies the *supra-marginal convolution* (Fig. 4847, P²). Below the posterior portion of the intra-parietal, and behind the superior extremity of the horizontal limb of the Sylvian fissure, lies the *angular gyrus* (Fig. 4847, P³).

The *temporo-sphenoidal lobe* is divided horizontally, by the *superior* and *inferior temporal sulci*, into three convolutions, first, second, and third, or *superior*, *middle*, and *inferior temporo-sphenoidal convolutions*. On the median aspect of the hemispheres the *calloso-marginal fissure* (Fig. 4848) has above it the *marginal convolution ;* below it, and immediately above the corpus callosum, lies the *gyrus fornicatus.*

Reid's Method.—Reid's "base line" (Fig. 4862) is a line running backward from the infra-orbital ridge through the middle of the external auditory meatus, and prolonged to the middle line of the head posteriorly. The *fissure of Sylvius* runs from a point an inch and a quarter behind the external angular process of the frontal bone to a point three-fourths of an inch below the most prominent point of the parietal eminence. Measuring from above backward, the first three-fourths of an inch will represent the main fissure; the rest indicates the horizontal limb. The ascending limb starts at a point three-fourths of an inch back of the anterior extremity, that is, two inches behind and slightly above the external angular process, and runs vertically upward and forward about one-fourth of an inch.

To find the *fissure of Rolando,* draw the base line and the lines for the great longitudinal fissure and the fissure of Sylvius. Then draw two lines perpendicular to the base line; one from the depression in front of the external meatus (Fig. 4862, D E) and the other (F G) from the posterior border of the mastoid process at its root. We shall thus have on the surface of the head a four-sided figure, bounded above and below by the lines for the longitudinal fissure and the horizontal limb of the fissure of Sylvius, respectively, and in front and behind by the two perpendicular lines just described. Next draw a diagonal line (F H) from the posterior superior angle to the anterior inferior angle. This corresponds to the fissure of Rolando, which, however, as a rule, does not quite join the fissure of Sylvius.

Cunningham[6] states, however, that this (Reid's) mode of locating the fissure of Rolando is not reliable, and I much prefer Horsley's or Hare's myself, both as more accurate and much more easily applied.

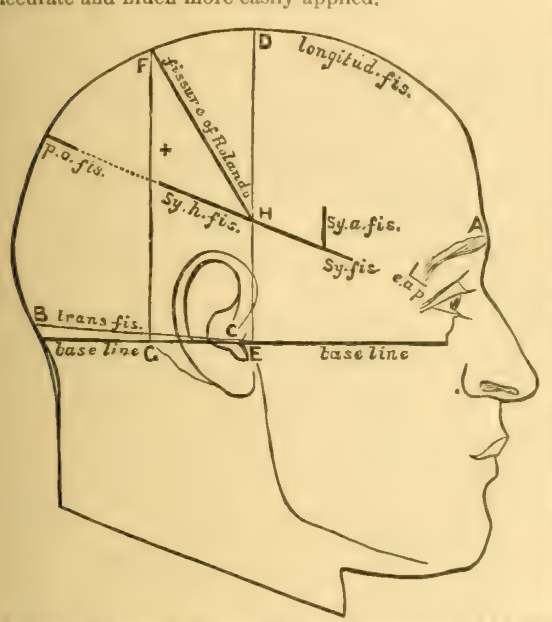

FIG. 4862.—A, Glabella: B, external occipital protuberance; *e.a.p.*, external angular process of frontal; B C, transverse fissure; A B, longitudinal fissure; *Sy. fis.*, Sylvian fissure; *Sy. h. fis.*, horizontal limb of fissure of Sylvius; *Sy. a. fis.*, ascending limb of fissure of Sylvius; D E, perpendicular line from depression in front of external auditory meatus to middle line of top of head; F G, perpendicular line from posterior end of base of mastoid process to middle line of top of head; F H, fissure of Rolando; *p. o. fis.*, parieto-occipital fissure; +, most prominent part of parietal eminence. (Reid.)

To find the *parieto-occipital fissure* continue the line for the horizontal limb of the fissure of Sylvius (Fig. 4862, *Sy. h. fis.*) to the line of the longitudinal fissure. The portion of this line, about an inch long, next to the longitudinal fissure, will usually approximately correspond to it. The position of the various convolutions can now be readily indicated by reference to Fig. 4863;

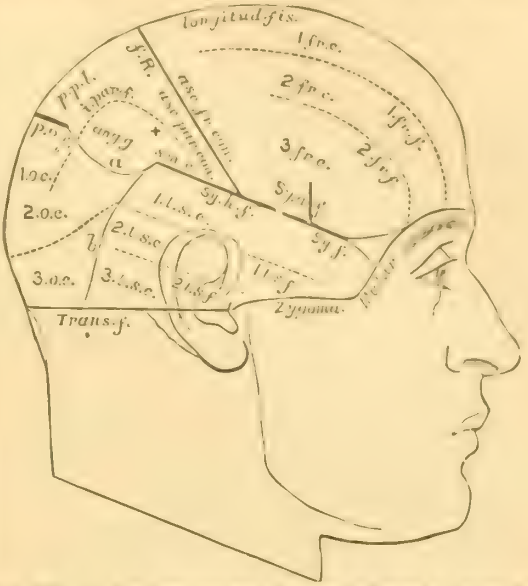

FIG. 4863.—+, Most prominent part of parietal eminence; *a*, convex line bounding parietal lobe below; *b*, convex line bounding temporo-sphenoidal lobe behind; 1 *fr. c.*, first frontal convolution; 1 *fr. f.*, first frontal sulcus; *f.* R., fissure of Rolando; *Sy. f.*, Sylvian fissure; *Sy. h. f.*, horizontal limb of Sylvian fissure; *Sy. a. f.*, ascending limb of Sylvian fissure; *p. o. f.*, parieto-occipital fissure; *i. par. f.*, intra-parietal sulcus; *ang. g.*, angular gyrus; *s. m. c.*, supramarginal convolution; 1 *t. s. c.*, first temporo-sphenoidal convolution; 1 *t. s. f.*, first temporo-sphenoidal sulcus; 1 *o. c.*, first occipital convolution; *p. p. l.*, postero-parietal lobule. (Reid.)

Hare's Method.—Mr. A. W. Hare has pointed out that neither the cranial sutures nor the prominences of the face are available for mapping out the brain; the former, because they are too indistinct or obliterated, the latter, because they have no direct relation to the cranium as a whole on account of the unequal development. The same observation, he points out, is true of the bony landmarks on the lower portion of the skull. If the external auditory meatus or mastoid process have lines drawn on them over the convexity of the skull they will give inconstant results according as the anterior or posterior portions of the head are more or less developed. Four points, however, are of value, viz., 1, the glabella, which corresponds to the base of the anterior lobe of the brain; 2, the inion, which corresponds to the base of the posterior lobe of the brain, and also to the junction of the falx with the tentorium; 3, the third constant landmark is the external angular process of the frontal which limits the cerebrum laterally and has also a uniform relation to the fissure of Sylvius; 4, finally, the parietal eminence is valuable, since it marks the greatest lateral expansion of the brain, and bears a special relation to the supramarginal convolution. While its cranial relations vary considerably, its cerebral relations are much more constant. The distance from the glabella to the upper end of the *fissure of Rolando* will be 55.7 per cent of the total distance from the glabella to the inion. For instance:

If the distance from the glabella to the inion is	The distance from the glabella to the upper end of the Rolandic fissure will be
11 inches	6.1 inches
11½ ..	6.4 ..
12 ..	6.6 ..
12½ ..	7.0 ..
13 ..	7.2 ..

In other words, however the proportions of a head may differ, the pre-Rolandic and post-Rolandic regions of the brain are uniformly proportionate to one another, the pre-Rolandic being 55.7 per cent., and the post-Rolandic, 44.3. Moreover, the fissure of Rolando runs downward and forward at an angle of 67°, and its average length is 3½ inches.

Dr. Charles Wilson, of Tunbridge Wells, has introduced a cyrtometer (Fig. 4864) consisting of two strips of flexible metal forming a letter T, with a tape to secure the short horizontal limb in place, the mode of using which is shown in Fig. 4865. On the antero-posterior arm it will be noticed that there are two scales. The posterior scale is lettered in capitals from A to Q. The anterior scale is lettered in small letters from a to q, and they are so placed that from the glabella the distance from the glabella to small a, b, c, etc., is 55.7 per cent. of the distance from the glabella to capital A, B, C, etc. The instrument being placed on the forehead, so that its inferior border corresponds to the glabella, if the capital letter A falls over the inion, then the small a will correspond to the beginning of the fissure of Rolando, and so on for the other letters. The small strip for marking the fissure of Rolando is movable on the antero-posterior limb, and is [illegible] to [illegible]. This is now slid along until it corresponds, for instance, to the small a, when its anterior border marks the line of the fissure of Rolando. Similarly, if the inion corresponds to B or C, the Rolandic strip is slid to b or c, etc.

The Fissure of Sylvius.—To find this fissure a line is drawn from the external angular process backward to the occipital protuberance (Fig. 4866, Eap to OPr) by the shortest route between these points. This line dips a little toward the external auditory meatus in escaping the great convexity of the skull, which convexity lies in the course of the above horizontal line between these two bony prominences. It usually passes about half an inch above the meatus, and thus closely corresponds to the floor of the middle fossa at this point. In front of the meatus it lies above the level of the floor of the middle fossa; behind it, it runs parallel to, and nearly coincident with, the attachment of the tentorium and the posterior half of the lateral sinus. A point 1¼ inch posterior to the external angular process on this line marks the commencement of the fissure of Sylvius, [illegible] in heads of the most varied shapes and sizes this measurement remains constant. From this point a straight line to the centre of the parietal eminence marks accurately the course of the posterior limb of the fissure, and nearly corresponds in part with the squamo-parietal suture (Fig. 4866, SF). The ascending limb of the fissure corresponds closely with the squamo-sphenoidal suture in its entire length, and is continued upward in the same line for half an inch (A). The middle meningeal artery is also shown in Fig. 4866 in its relation to the Sylvian and Rolandic fissures. To expose the tip of the temporo-sphenoidal lobe, trephine behind the upper extremity of the great wing of the sphenoid (TS). To expose Broca's convolution, trephine immediately in front of the great wing of the sphenoid (B).

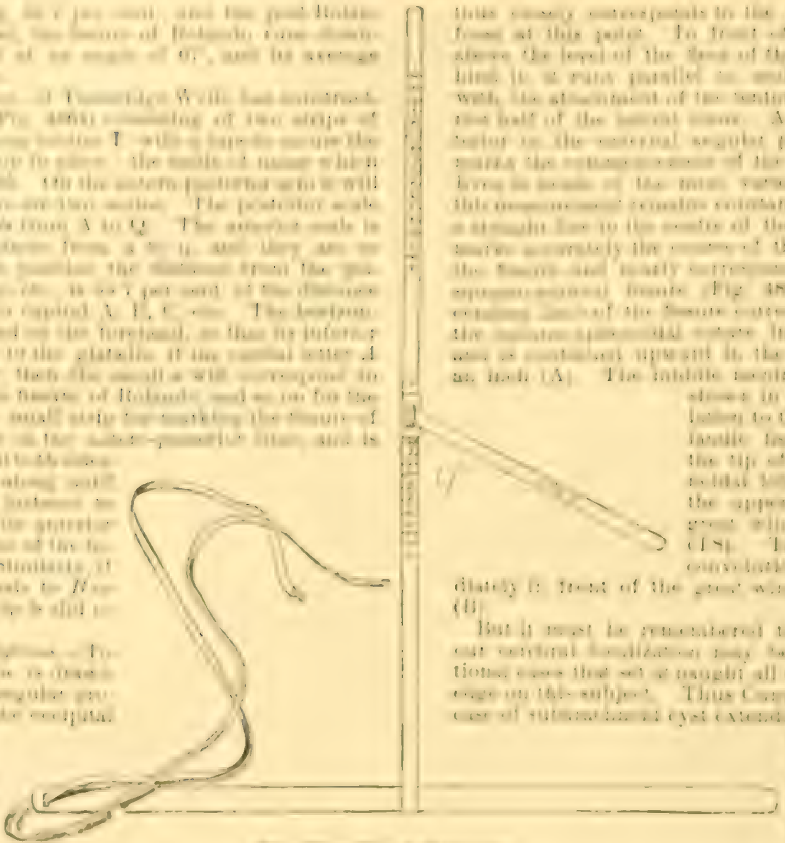

FIG. 4864.—Wilson's Cyrtometer.

But it must be remembered that however exact our cerebral localization may be, there are exceptional cases that set at naught all our present knowledge on this subject. Thus Cunningham[1] reports a case of subarachnoid cyst extending from the fissure of Rolando to the occipital lobe with neither motor nor sensory disturbance, and Bramwell[2] reports a case of sarcoma of the [illegible] destroying the greater part of the motor centre without any paralysis. These and a small number of

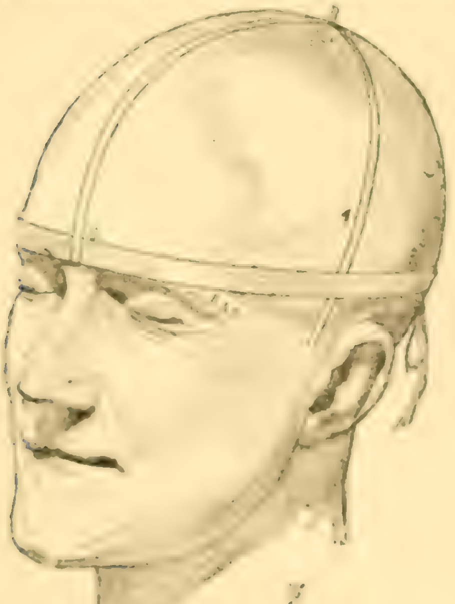

FIG. 4865.—Wilson's Cyrtometer in situ. G, glabella; EAP, external angular process; R, fissure of Rolando, its position and direction marked by the movable strip of metal.

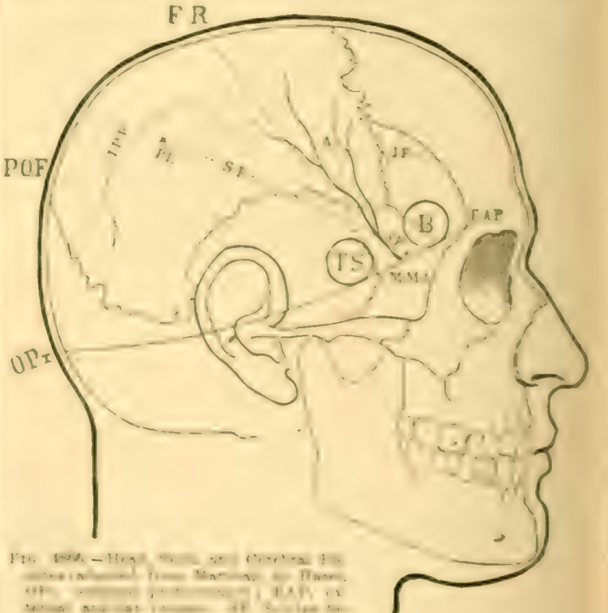

FIG. 4866.—Head, Skull, and Cerebral Fissures (adapted from Macewen, by Rawe). OPr, occipital protuberance; EAP, external angular process; SF, Sylvian fissure; A, its ascending limb; FR, fissure of Rolando; PE, parietal eminence; MMA, middle meningeal artery; TS, tip of temporo-sphenoidal lobe; B, Broca's convolution; IF, inferior frontal sulcus; POF, parieto-occipital fissure; IPF, intraparietal sulcus. The place where the circles are drawn [illegible] those indicating the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones.

other such cases should make us careful not to be too dogmatic until we learn much more.

Percussion of the Skull.—Here, perhaps, as well as elsewhere, may be noted a point to which Macewen[9] has called attention, viz., that percussion of the skull may afford valuable evidence of the condition of its contents, and, as I have pointed out,[10] of the condition of the skull itself, and as I have observed in a recent case, of the overlying tissues.

Macewen does not state the character of the percussion note, but presumably it is that when an abscess or tumor exists, there will be a local, increased dulness on percussion with a lower tone. Macewen states that it has been verified post-mortem, and that it will probably be of especial value in early life in the diagnosis of tumors of the cerebellum. In a case of hydrocephalus I have lately observed a markedly increased dulness of one side on percussion, and the post-mortem showed that the ventricular distention was far more marked on this side.

In simple fracture of the skull the "cracked-pot" sound described on p. 223 of this paper may be of service, and I would urge that it be tested and reported on in future cases.

In a case of syphilitic necrosis of the skull above the left ear, with a Jacksonian epilepsy in the left arm and leg, and therefore a presumable lesion (gumma ?) on the right side of the brain, I have recently tested the percussion note. Over the necrosed bone the tissues were somewhat thickened, but not to any excessive degree. The percussion note was so much duller on the left side, half way between the sagittal suture and the ear, that two of my assistants with their backs turned to the patient correctly stated which side was percussed, and the same difference was noted as between the same site and the forehead well above the frontal sinus. In a paper[11] published in 1884, I have pointed out the similar value of percussion in the so-called abscess in the frontal sinus and the antrum.

GENERAL TECHNIQUE OF OPERATIONS ON THE BRAIN.—This has been carefully formulated by Horsley.[12] In a few minor points[13] I have added to it from my own personal experience, as well as that of others.

I. *Shaving the Head.*—This is not only important for the operation, but should always precede a definite diagnosis, and, in fact, be one of the means of making it. So important do I regard this, that I should consider no diagnosis as assured, and no operation warranted, that had not been preceded by shaving. The unexpected and the unknown scars found have surprised me in several cases. Besides this, no reliable mapping on the head of the fissures and convolutions can otherwise be made. These should always be marked on the skull by an aniline pencil.

II. *Antiseptic Preparation of the Patient.*—The day before the operation the patient's head should again be shaved, scrubbed by a nail-brush with soap and water, next with ether, and then be covered with a wet sublimate dressing (1 to 2,000), retained in place by a bandage till the time of operation. Formerly I used, as Horsley advises, a solution of 1 to 1,000, but I have found that the recently shaved scalp is so tender that an eruption was often caused by it—a dangerous prelude to an intra-cranial operation. This scrubbing must be gentle, but thorough. The operation-room should be uncarpeted and should contain only necessary furniture, the walls and ceiling should be carefully wiped the day before, and all the wood-work and furniture scrubbed with carbolic solution. Clean sponges that have been disinfected and kept in a carbolic solution (1 to 20) should be used, and best with a sublimate solution (1 to 1,000) at the operation. The instruments may be disinfected either by boiling for fifteen minutes, or by lying for an equal length of time in a carbolic solution (1 to 20), and then transferred to boiled water sufficiently cooled to permit of their being handled. The spray may be entirely omitted—on this point I speak advisedly. The head should be washed with soap and water, ether, and sublimate solution, a second time just before the operation. The hands, and especially the finger-nails of the operator and of everyone of the assistants, should be most carefully cleaned and then disinfected by soap and water then dipped in alcohol, and while wet be scrubbed with a sublimate solution and nail brush. So efficient is this disinfection that in one of my brain cases both I and my chief assistant being compelled to operate upon a case of fecal fistula the day before the brain operation, we repeatedly disinfected our hands before the operation on the brain, and the patient was out in the street on the eighth day.

III. *Anæsthetic.*—Horsley specially advises the use of chloroform, but in the eleven cases that I have thus far operated upon, I have used ether and found no reason to regret it. Horsley[14] cautions us that when the dura is opened there is a special sensitiveness to the action of an anæsthetic (chloroform only ?) and that special care should therefore be used not to give too much.

As a preliminary Horsley advises that a quarter of a grain of morphine be injected under the skin from a half hour to an hour before the operation, both because a smaller quantity of anæsthetic will be required, and also because it produces contraction of the arterioles, and consequently diminishes hæmorrhage. As Nancrede has pointed out, however, the use of opium, at least in cases in which a small definite cortical centre is to be removed and but little hæmorrhage is anticipated, is not advisable. Horsley[15] states that it is dangerous to operate upon patients under the influence of drugs, and especially the bromide of potassium ; why, I do not know ; but I should be inclined to follow so high an authority. In my own operations I have also used (and I think with advantage) ergot by the mouth, of which I would advise a dose of from two to four drachms.

IV. *Marking the Bone.*—This can be done in two ways : 1. The site of the scar or other lesion is easily marked by making a small incision down to the bone and then marking it by an aniline pencil as done by Weir ; or better, I think, as I have proposed, by nicking the bone by a gouge. To mark the Rolandic and other fissures of the brain, the same method may be employed by means of two or more small nicks. These nicks may also be useful in other ways. In my first case (tumor), as I was not able to replace the button of bone, I utilized the nick to fix accurately the location of the tumor. There was a scar, the situation of which was exactly determined by measurements. A nick on the button of bone was made at the site of the scar. After the operation the button of bone was fitted to the tumor, and the dimensions of the tumor measured from the nick. These measurements were afterward transferred to another skull, upon which the site of the scar was accurately fixed, and upon which, also, the fissures of the brain had been marked. I was thus able to locate, with great accuracy, the position of the tumor. 2. Another method of marking the fissures (especially the Rolandic) is by drawing them on the scalp with an aniline pencil, and prolonging the lines above and below the limits of the intended flap. When the flap is raised all the other external landmarks are practically lost ; but a nick in the bone, or an imaginary line adjoining the aniline lines of the Rolandic fissure beyond the limits of the flap, will give us this important landmark.

V. *Access to the Brain.*—Instead of the old crucial incision Horsley has recommended a large horse-shoe-shaped flap, which will usually be about three inches or more in diameter. This incision must be carried vertically down to the skull, and must be so made, first, as to favor drainage in the supine position. Secondly, its base should be so placed as to retain the most favorable blood supply to the flap. Horsley has recommended that the periosteum be not raised with the flap, but reflected by a later crucial incision. I have, however, always reflected the periosteum with the flap, and have found no ill results. It is a cardinal principle in the new cerebral surgery, that both the flap in the scalp and the opening in the bone shall be ample. The mode of dealing with the bone will be mentioned later ; but let it once for all be stated that a large opening in the bone has been amply proved to be no more dangerous than a small one, and an immense advantage can be gained in locating the fissures and the convolutions (and therefore the lesions), and, so to gress in the direction of "silent areas" for operative procedures. This is of the greatest practical service.

Different methods, however, may be adopted for making the opening in the bone. A large trephine, one and one-half, two, or even two and one-half inches in diameter, may be used. If the smallest of these sizes be used, it may necessitate the removal of two adjacent buttons, and even then the opening may have to be enlarged in any given direction for access to the lesion. This is best done by the ordinary rongeur forceps, or by Hopkins's modification of them. These forceps have

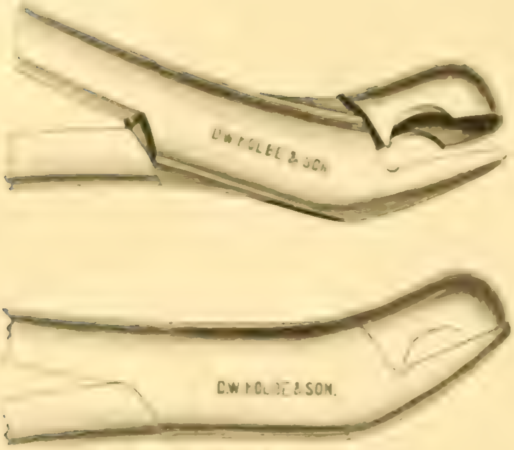

FIG. 1867.—Hopkins's Rongeur Forceps.

been further modified (and I think with advantage) by Weir, by making the bend at right angles to the handles of the forceps instead of in their plane.

Another method is one that Mr. Horsley has lately used, and which has the advantage of abridging the time required for the operation. He makes a one-inch opening with a trephine, and by this determines the thickness of the skull. He then outlines the piece of bone to be removed, by Bonwill's surgical engine, cutting almost through the bone. Complete division of the bone is then effected by stout bone-forceps.

The German surgeons frequently use the chisel and hammer, but this I certainly consider dangerous, both on account of the possible contusion of the brain and also from the mechanical violence required by the chisel.

Of course, in trephining for abscess only a three-fourth inch trephine would be necessary, and the opening can be enlarged, if necessary, by the rongeur forceps. For tapping the ventricles a half-inch opening is ample. V. Bergmann has declared himself opposed to operative interference with a cerebral tumor which would require a large opening in the bone, on account of the probable subsequent œdema. The best answer to this is that success has practically followed operations in which large openings have been made and, as a rule, no œdema has followed. Horsley has thus successfully removed a tumor of four and a half ounces, and I have done the same in a case of a tumor weighing [illegible]. Indeed, in some cases pre-existing œdema has been relieved.

It is quite surprising how far beyond the limit of the opening in the bone and dura we can feel and see. The brain admits gentle pressure very readily. A finger can be inserted for nearly an inch all round the opening, and the eye can reach as far if the brain be gently depressed by any flat instrument.

Before enlarging the opening the dura mater must be separated from the bone. This can be done with a blunt probe, but the best instrument is one devised by Horsley (Fig. 1869), for it uses the under-surface of the surrounding bone as a fulcrum for any lever-like use.

The dura should, as a rule, be opened. Unless this is done important information may be lost, and the case be improperly treated. Occasionally it may be allowed to remain intact, when, for instance, a sufficient lesion has been discovered. But it is a rule, with rare exceptions, that if we trephine at all, the membrane should be examined. The opening in the dura should not be by a crucial incision except in case of a small opening for abscess of the brain or draining the ventricles, but by a horseshoe-shaped incision at about a quarter of an inch away from the margin of the bony opening. The dura should first be lifted by a tenaculum and slightly opened by a scalpel, and the incision then be completed by a pair of blunt-pointed curved scissors. The dura should be carefully lifted by forceps so as not to wound the veins beneath, and the same caution applies to the scissors. Should it be necessary to cut across the trunk or any branches of the meningeal arteries, they should be secured by ligatures passed through the dura mater by a needle, and tied before the vessel is cut across, the dura being well lifted meantime, lest the needle wound the large veins in the brain. When the operation is terminated, if the dura has not been removed, it should be replaced and secured by catgut. To facilitate this I have had made a small curved needle with an eye in the point. This, I find, answers admirably. The ordinary needles are of too large a radius.

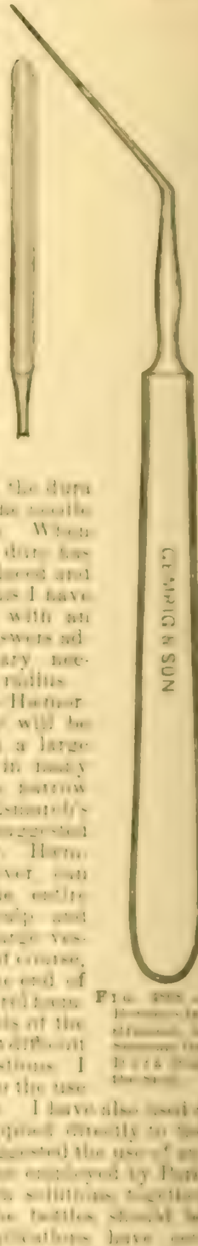

FIG. 1869.—Horsley's Dura Elevator, for Separating the Dura from the Skull.

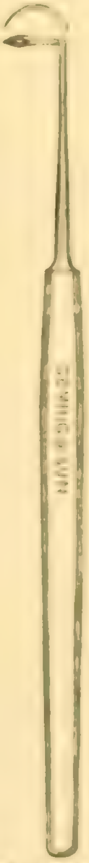

FIG. 1868.—The Author's Dura Needle.

VI. *Hæmorrhage.*—Hæmorrhage from the scalp will be very free. It can to a large extent be prevented in many cases by the use of the narrow band furnished with Esmarch's bandage, as has been suggested by Dr. M. Allen Starr. Hæmostatic forceps, however, can with safety grasp the entire thickness of the scalp and quickly control any large vessels. Such as need it, of course, should be ligated at the end of the operation. To control hæmorrhage from the vessels of the brain, one of the most difficult of all the operative questions, I have already alluded to the use of morphine and ergot. I have also used a solution of cocaine applied directly to the brain. I have also suggested the use of antipyrin, which has been employed by [illegible] with advantage. Such solutions, together with the sponges and the bottles, should be sterilized. These applications have certainly proved advantageous in checking hæmorrhage from the smaller vessels, nor could I see any harm resulting from them when I have used them. The cocaine should be a ten per cent. solution. Another means is boiling water cooled to 110° or 120° F. This I have used very liberally and have found no disadvantage from the comparatively high temperature. Pressure is another means which can be constantly and successfully applied by sponges or by iodoform or other gauze.

But after all, the chief reliance is to be placed on ligatures of catgut. They should not be chromicized, but prepared after the manner of Kocher or Martin. The method of applying them is very important. While the larger arteries in the brain can be ligated in the usual way, the veins, which are very large, very full, and very fragile, are a much more troublesome source of hæmorrhage, and require much more delicate manipulation. The greatest gentleness must be used during traction; and in tying, the traction on the two ends of the ligature must be exactly even or the vessel will be torn. In addition, the knot must only be drawn tight enough to stop the hæmorrhage, for if drawn too tightly it will easily cut through the fragile vessel. Weir has suggested in some cases the application of clamps to the vessels for twenty-four hours. My experience makes me doubt whether they would hold in such fragile tissue. The tossing of the patient's head might also displace them and involve a possible danger to the brain itself. Besides this, they would interfere with the immediate closing of the wound, which is especially to be sought in order to avoid a hernia cerebri and secure the most rapid healing possible of the wound.

It is occasionally necessary to trephine very near, or even over, one of the great sinuses of the brain, and in doing so it might easily be wounded. The sinus, however, may be avoided if due care be used. The trephine should be applied far enough from the sinus to be in a region of absolute safety. The opening can be enlarged later toward, or even over, the sinus with safety. In a recent case I recognized when I was near the lateral sinus by feeling the bony groove in which it is lodged by my finger introduced through the trephine opening. I could then separate the dura and sinus from the bone and could have trephined safely over the sinus, had it been necessary. In addition to this we may have to deal with a primary wound of a sinus itself. If the opening in the sinus is small, lateral ligation of the sinus may be practised, as has been done by Parkes[16] and Brinton.[17]

Pressure by a tampon of iodoform or other gauze has controlled it in a number of instances.[18] In some cases the sinus has been tied by two ligatures, one in front and one behind, thus cutting off all possible hæmorrhage, and the sinus excised as by V. Bergmann and Küster.[19] Barr[20] has even suggested that in cases of thrombosis of the lateral sinus we may purposely open it after ligation, clean out the clot and remove this portion of the sinus. Considerable further experience will be necessary before we can decide whether this will be of any advantage. Its possibility, however, as a surgical procedure seems well assured. Care should be taken that no air enters the sinus lest sudden death should follow, as in Volkmann's case.[21] In the same volume a series of nine experiments are reported on dogs by Genzmer, in which there was aspiration of air in six. See also Senn's experiments.[22]

VII. *Treatment of the Brain.*—The first practical point to notice, after the dura is opened and hæmorrhage controlled, is whether the brain *bulges* into the trephine opening. If it does so, it indicates a pathological increase of the intracranial pressure, a fact of the highest importance, since it will indicate either a tumor, abscess, blood clot, or dropsy of the ventricles. Bulging of the dura before opening it, is, of course, equally significant.

Next, the *color* of the brain should be observed. A yellow tinge or lividity will probably indicate a tumor beneath the cortex. If the brain tissue be the seat of an old laceration its color will be altered, usually a dirty yellowish-brown. Next, the condition of the vessels and the perivascular lymphatics must be observed, and particular notice be taken if there are any yellow-white patches on them that may indicate any old mischief. Sometimes the membranes and convolutions will be densely matted into a yellowish cicatrix. In a number of cases I have seen *œdema of the membranes* sometimes so great as to obscure the sulci and convolutions to a marked extent. Precisely its significance, how far it is normal and how far pathological, I do not yet know. Nicking or snipping the membrane allows the serum to escape, and the sulci and convolutions to be recognized.

Next, the *density* of the brain must be appreciated by the touch. If there be an abscess or dropsy of the ventricles the elastic tension will be increased, but, at least in dropsy, it will be very soft. If there be a large tumor the brain substance will be more resistant and dense than normal. But it must be remembered that a small cerebral tumor at any distance beneath the cortex can scarcely be detected by this means. Should any hardness be detected, the brain substance must be incised and careful search instituted by the finger for the tumor or other pathological condition. If the finger be used it should be the little finger by preference, and great gentleness should be employed, or serious laceration of the brain substance will be produced. If abscess or dropsy be suspected the brain may be explored by a needle, knife, or grooved director. (For their comparative value, see p. 217.) Wright,[23] after trephining over the occipital lobe, even thrust a trocar through the tentorium down into the cerebellum and evacuated an abscess—a procedure I should not employ; trephining over the cerebellum itself would have been safer and better.

Next, the presence or absence of *pulsation* in the brain is to be noted. If a large tumor, abscess, or cyst exist it will be absent, but if a small tumor, cyst, or abscess be separated from the surface by any considerable layer of normal brain tissue, pulsation may be present. Altered brain tissue from old lacerations, etc., will generally pulsate.

In incising the brain, the knife should be carried down vertically into the corona radiata in such a manner as to avoid damage to the fibres coming from adjacent portions of the cortex, and the incision should run as nearly as possible parallel with the cerebral vessels which are "terminal."

Should the brain tissue be abnormal, the whole abnormal portion must be removed. It is important in doing this to remember that, while we should guard against producing any needless paralysis by removing healthy brain tissue, yet it is of prime importance that *all* of the diseased portion should be removed. If there be a cortical tumor (unless it is encapsulated or otherwise definitely limited), the necessity of removing a portion of adjacent and apparently healthy brain tissue, so as to get beyond the limits of infiltration, is of the greatest importance. If the tumor be subcortical, it can be sought for by the finger with great gentleness, and be removed either by a sharp spoon or other similar means, together with a suitable adjacent zone of healthy brain tissue. In all this removal of tissue adjacent to the tumor we can cut much more freely antero-posteriorly than vertically. In the vertical direction we encroach far more quickly upon adjacent additional centres than we do in the antero-posterior direction.

VIII. *Recognition of the Brain Centre Sought for.*—In certain cases of Jacksonian epilepsy the object sought for is the removal of the centre whence the discharging lesion starts. In this case it will be necessary to recognize such centres by definite methods. In some cases the membranes and the convolutions are so matted together, and the brain substance so altered, that it will be impossible to recognize the sulci and the convolutions. But in these cases it is scarcely necessary to do so, inasmuch as all the damaged tissue should be removed, and, as before stated, we must even encroach to some degree upon apparently healthy brain tissue. In other cases, however, it is important and also possible to recognize the individual sulci and the convolutions, and to determine the precise part of the brain that is the seat of the discharging lesion, and therefore to be removed. The prolonged aniline lines on the undisturbed portion of the scalp, indicating the position of the fissure of Rolando, or the reapplication of the cyrtometer will here assist us very materially.

In only four published cases, up to the writing of this paper (December, 1888), has this been done, viz., by Horsley,[24] Keen,[25] Deaver and Lloyd,[26] and Nancrede,[27] and in each case most satisfactorily. This is best accomplished by means of an ordinary faradic battery. In order more handily to use this means of diagnosis, I have had made a little rubber handle with two insulated points, the stems of which, being flexible, can be bent toward each other or separated as far as desired (Fig. 1870).

A very important point in this relation is stated by Horsley as the result of his experiments on animals. The cortex of the brain soon loses its excitability to electricity almost when bathed with antiseptic solutions. In any such case, therefore, it is desirable that the search for such cortical centres, by means of electrical stimuli, should be done immediately after the opening of the dura, and before any antiseptics have been applied. Possibly hot water may be necessary to check the bleeding; but experience will have to decide whether this also may not dull the excitability of the cortex, though it does not seem probable that it does. When such centre is found, I have suggested, in order to prevent the need for repeated and possibly injurious applications of electricity, that the desired centre be marked by an aniline pencil or a stitch. If the centre is to be preserved the latter would do no harm.

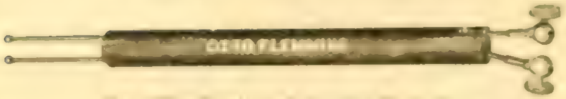

FIG. [illegible].—The Author's Insulated Electrode.

IX. *Photography of the Brain.*—This can readily be done by an ordinarily expert amateur. Dr. Morris J. Lewis and Dr. J. K. Mitchell have helped me in the several cases which I have photographed, and we were of the opinion that the exposure should be practically instantaneous, and with the most sensitive plates made. Even with such plates there may be difficulty on a cloudy day, and the danger of the patient's moving and the constant oozing of the blood, make it necessary to have the shortest exposure possible. "Flash powder" (Blitz Pulver) or the very handy magnesium flash-lamp may be used; but if employed, the possible firing of the ether should be borne in mind. In the hands of a competent assistant, the photographing is scarcely any interruption to the operation. But I have been disappointed in the results. It has given me no good details of the field of operation, owing chiefly, I think, to the wet, glistening curved surfaces, and the deep shadows at the point of excision. I would prefer to have a rapid sketch made by a good artist, who is at the same time an anatomist.

X. *Drainage.*—The question of drainage of the brain is a most important one, but should be conducted on precisely the same principle as drainage for other parts of the body. It can be dealt with in two different ways. How important it is may be seen by the fact that in 20 cases of trephining reported by Amidon, in which free drainage was employed, 18 (ninety per cent.) recovered; while in 29 fatal cases, in only 2 (6.8 per cent.) was drainage specifically mentioned, and in the other 27 (93.2 per cent.) no mention is made of it; but it should be added that 11 of these were almost certainly fatal.

(1) In case of removal of a tumor or of a portion of the brain substance for epilepsy, or for oedema, the best results are obtained by combined tubular and capillary drainage, as described by me in a paper read before the Philadelphia Academy of Surgery.

Mr. Horsley has insisted that, in such wound cavities, drainage should not be carried on by the tube for more than twenty-four hours. The arguments that he presents in his papers above referred to, and from which I have freely drawn, are in favor of this method of procedure, and have been verified by results in a number of cases. Drainage is especially important in cerebral surgery, where we wish to secure union by the first intention, and thus to secure a certain amount of counter-pressure on the brain, which is tending to force itself out of the opening by intracranial pressure, and produce hernia cerebri. We also desire that the flap of skin shall be separated from the brain beneath by a cushion of soft connective tissue. These conditions are best obtained by allowing a certain amount of [illegible] in the wound [illegible] within the cavity. During the first twenty-four hours there is steady oozing of blood and serous fluid from the cut surfaces. This is best removed by a rubber drainage-tube at the most dependent point of the incision, as the patient will lie in bed. Before closing the wound, I therefore always introduce a rubber tube of about the calibre of a lead-pencil, and alongside of it a bundle of horse-hairs. As is my habit in all other wounds, I dress it at the end of twenty-four hours, and at that time remove the tube, leaving the horse-hairs in place. If the wound fluids subsequently collect in the cavity to any extent, so that the patient complains of pain and throbbing in the wound, Mr. Horsley gently opens the track of the drainage-tube with a probe, and relieves the tension in this manner, without at the same time producing an opening large enough to permit a hernia cerebri. My own method is to retain the horse-hairs in place for about three to five days. They are not irritating, and they serve the purpose of slight capillary drainage, after the same fashion as the probe. In his later operations for the removal of tumors or epileptogenous centres, Horsley has even omitted all drainage except by the omission of a stitch or two, and has trusted that the arachnoid, like the peritoneum, will absorb the effused fluids. Of course, in case of abscess, wounds, intracranial haemorrhage, etc., drainage must be most carefully provided for even by counter-openings, and be much longer maintained, as pointed out in those sections.

In cases of operations on the brain I have usually, but by no means always, found considerable bulging of the flap during the first few days after the operation. This bulging, if it does not become too great, is not to be interfered with. If the wound is reopened, at the end of a few days (as I did in my case of tumor, and I now think unadvisedly), we shall find a cavity filled with delicate, spongy, pink, connective tissue, which forms an elastic barrier between the scalp and the brain. The horse-hairs pass through this tissue, and by their slight drainage remove any undue exudation.

(2) In cases of abscess, gunshot wounds, haemorrhage, etc., or in cases where there is danger of infection, the drainage must be more prolonged, and is best accomplished by rubber tubing. For the method of drainage in these conditions the reader is referred to other portions of this paper under the headings mentioned.

XI. *Replacement of the Bone.*—The wisdom of replacing the bone is still a question *sub judice*. Mr. Macewen first showed the possibility of replacing the bone by mincing it up into small pieces and spreading it over the surface of the reunited dura. Clark, of Glasgow, was the first, I believe, to replace the entire trephine button with success. In the case of replacement the utmost care, however, must be given to the button from the moment it is removed to its replacement. The instant that it is removed it should be placed in a cup containing a warm solution of bichloride (1 to 2,000), or an equivalent solution of carbolic acid (1 to 40), or artificial blood serum, as suggested by [illegible]. This cup should be placed in a large basin in which lies a thermometer, and hot water be poured into the outer basin from time to time to keep the temperature always between 105° and 100° F. It should be the duty of one assistant to attend to nothing else but to the water in this basin. All small fragments are also placed in this cup, and when the dura has been sutured the large disks of bone may be replaced, together with a suitable number of the small fragments bitten away by the rongeur forceps. If there be more than one large button, unless it is absolutely necessary, the triangular spur or spurs between the trephine holes should not be removed unless necessary to get more room, as they assist materially in keeping the buttons in their proper places. Should the pericranium be removed, the bone cannot be thus replaced. In one case, I successfully adopted the following expedient: I bored the centre-pin hole completely through the bone, and at the margin of the disk made another hole, also by the centre-pin of the trephine. The two ends of a chromic catgut ligature were passed through these openings, and by needles these two ends were passed through the scalp and tied on the outside. The union to the scalp was complete, and the aperture in the skull was almost entirely closed by the callus. If the opening, after removing the disk of bone, has been enlarged by the rongeur forceps, the small fragments cannot be secured in this manner, but it is entirely possible to fill up any small gap by a button from the back of a lamb's skull, trimmed by a rongeur forceps to suit the opening, and secured in the same way; I find that the back of a lamb's skull has nearly the same curve and thickness as a man's. One good button can be gotten from it, and it is possible that two might be obtained at a pinch.

In my third case I replaced a large button and about fifteen pieces bitten out by a rongeur forceps, and the skull was so completely restored that, excepting for the scar and a slight flattening of the skull, one would not know that it had ever been trephined. Figs. 4871 and 4872, in the so far unique case of Burrell,[31] show how complete the union may be after replacement of a trephine button. Further experience will prove whether the restoration and integrity of the skull, together with the slight flattening which probably will always accompany it, is more desirable than leaving the aperture protected only by the scalp. The restoration of the skull to its natural condition would seem to be most desirable, but inasmuch as some flattening may, and in most cases does, take place, whether this will do any harm is a question which must be decided by a larger experience. If the skull prove to be very thick, and chiefly of compact tissue, I should certainly very much question the advisability of replacing the button of bone. One such case I have known to become necrosed after seeming union for about ten weeks, but there were other complications in this operation which vitiated the result, independently of the character of the bone-disk. In case the bone is not replaced it will be well for the patient to wear a skull-cap into which is sewed a metal plate somewhat larger than the opening, as a protection against blows and falls. If a drain-tube has to be placed under the bone, a piece should be bitten out of its edge by the rongeur forceps to allow for the passage of the tube.

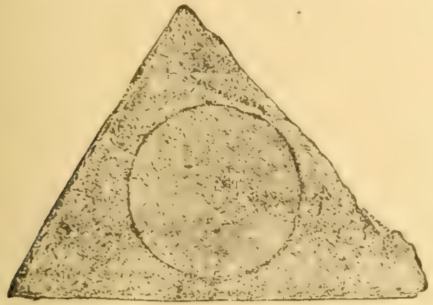

FIG. 4871.—Replaced Button of Bone. Inner surface.

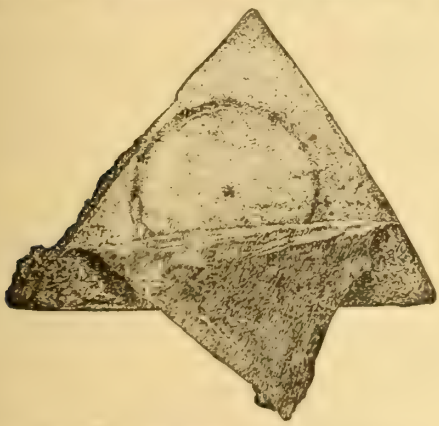

FIG. 4872.—Outer Surface of the same Button.

XII. *Closure and Later Treatment of the Wound.*—Hæmorrhage having been checked, the dura sutured as described on p. 210, and the bone replaced with provision for drainage, the scalp should now be replaced and secured with either catgut or disinfected silk sutures, with a number of strands of horse-hair placed between the scalp and the bone. An abundant dressing covered with "rubber dam" or "mackintosh" (though on account of the cloth in the mackintosh I prefer "rubber dam") is to be applied and retained in place by suitable bandages. The dressing will most probably be saturated with blood and serum at the end of a few hours. If so, the wound should be redressed. At the end of twenty-four hours the wound should always be redressed, when, as already directed, the drainage-tube is to be removed. The next dressing should not be done until the wound fluids have saturated the dressing to its margin. Should this not occur, however, by the fifth day, it is my rule then to redress the wound for the purpose of removing the horse hair, and also any stitches that may be no longer needed. In operations on the brain in which the bulging above referred to has produced some tension on the stitches, it is best not to remove them too early; but usually they may be taken out by the seventh or eighth day, and some of them by the fifth. If by the fifth day primary union has been secured, a mere protective sublimate dressing may be applied. In a few days this may be dispensed with, but the patient, on account of his shaven head, should wear a skull-cap, or some other means against taking cold.

XIII. *Rapidity of Recovery.*—If the case be not one with active inflammation, and if union by first intention has been secured, the patient should be well within a week or ten days, without an elevation of temperature much above 100° F., and possibly not even up to that point. The bowels and the diet should receive the ordinary care.

One thing is of the greatest moment after such operations. No excitement, study, business, household cares, or mental worry should be permitted for several weeks, or, better, for several months, after the operation. As yet, it is too early in the history of cerebral surgery to dogmatize upon this point, but we should certainly keep on the safe side and bar out any possible cause for harm for a long time.

XIV. *Secondary Operations.*—A few of these have been done. Mr. Horsley has referred to some in his paper. Nancrede[27] has reported one, and Stokes[4] another by Franks. The membranes will commonly be found to be quite adherent to each other and to the brain tissue, and if it be necessary to dissect them off the latter, it is almost inevitable that some portion of the outer layer of the cortex will be removed along with them, producing paresis in the centres thus encroached upon; hence, it should be done with the greatest gentleness and care. The cicatricial tissue between the brain and the bone very likely will be quite vascular, and, possibly, traversed by large veins. Should the dura not have been opened at the first operation, it will still be adherent to the brain itself, and probably covered by a layer of granulation and cicatricial tissue, which must be dealt with according to the needs of each case.

XV. *The Limits of Operative Interference with the Brain.*—Just how far we can safely interfere with the bones of the skull and with the brain, is as yet a question *sub judice.* Twelve years ago I perforated the squamous bone and passed a probe between the dura and along the petrous bone to a depth of two inches, in a search for an abscess. I found no pus, but the search did neither good nor harm. Weir[32] has proposed, in a case of aural disease with subsequent cerebral mischief, in a similar manner to lift the dura to a point corresponding to the roof of the tympanum; and if need be, in suppurative meningitis of the middle fossa, to open the dura and drain the fossa. He has well likened the petrous bone to the appendix vermiformis, as a focus of inflammation followed by suppurative processes in the dura or arachnoid, either local or general. It is followed, therefore, by external pachymeningitis and extra-dural abscess, internal suppurative meningitis, or cerebral or cerebellar abscess, all of which he suggests may be similarly relieved by operation. (See Extra-dural Abscess, p. 217, for the realization of this suggestion in that form of disease.) The same [illegible] has [illegible] and I have verified the [illegible] partly on the living and partly on the cadaver, that the cerebellum can be lifted far enough to obtain a view nearly to the foramen magnum; the same foramen can be reached by the finger on the inside, and from the outside both by the eye and finger; the longitudinal and lateral sinuses can be safely uncovered and separated from the skull, and the frontal lobe can be lifted far enough to expose the anterior clinoid processes.

Horsley has reached an aneurism of the artery almost at the optic foramen, and has stated that the tumor of the auditory nerve reported to the Neurological Society of London by Dr. Sharkey, could have been removed by division of the tentorium and ligature of the lateral sinus.

Other cases, in this paper and elsewhere, show that the sinuses may be torn and crushed; a very large part of the surface of the skull, up to even the size of the palm, or even more, may be taken out; large tumors, up to over four ounces, may be successfully removed, and considerable areas of brain tissue may be cut away with safety and advantage. How far this latter interference may be carried we cannot yet say with certainty, but in the at present so-called "latent zones," at least, it is probable that the interference may be much larger than is now believed.

A large portion of the base of the brain can certainly be explored by the finger, the eye, and the probe or director, and the substance of the brain can be punctured almost with impunity, repeatedly and to a depth of two and one-half inches, without leaving any injurious trace behind.

I have shown also that the lateral ventricles can be safely reached. Baldwin's case (p. 229) shows that even a wound involving them is not necessarily fatal.

Experience will doubtless add much to the above possibilities.

CEREBRAL ABSCESS.—In the first volume of this HANDBOOK there is a valuable article on Abscess of the Brain, to which I must refer the reader for more detailed information than I shall be able to give. But in the three years that have elapsed since that paper was published we have made great progress in the diagnosis, and especially in the treatment, of cerebral abscess, and this will justify somewhat of a seeming repetition.

Causes.—Nearly one-half of the cases of abscess of the brain arise from a suppurative process in the ear. Occasionally they arise from its acute inflammation; but much more frequently they are a sequel of chronic ear disease. Occasionally they will follow even a few weeks after suppuration, but they are far more commonly a sequel years after scarlet fever, or some other exanthem, has set up a discharge from the ear. The situation of such abscesses is most frequently in the temporo-sphenoidal lobe.

Barr, in 76 cases of cerebral abscess following disease of the ear, found 55 in the temporo-sphenoidal lobe, 13 in the cerebellum, 4 both in the cerebrum and cerebellum, 3 in the pons, and 1 in the peduncle. When situated in the temporo-sphenoidal lobe they are not necessarily directly in contact with the petrous bone, but may be separated from it by even an inch of apparently healthy brain tissue. They reach the cerebellum usually by the track of the lateral sinus, in which very often thrombosis occurs. The mastoid cells are very frequently, but not always, involved. The discharge is almost always fetid.

The next most frequent cause is injury. Frequently this injury has not been very severe, but even a small scalp wound, if it becomes septic, may involve the bone, the veins, or the [illegible], and then the encephalon. Moreover, if recovery apparently takes place, the patient is by no means safe, as a number of instances are on record where several weeks or months, and in some instances even a number of years, have elapsed between the infliction of the injury and the development of the abscess. A most remarkable case of late development of abscess, and of its correct localization, is given by Mr. Reginald Harrison in the *British Medical Journal*, April 21, 1888. A boy, aged *fifteen*, had received a severe blow on the *left* side of the head when *four or five years of age*. No severe symptoms followed the accident, but nine or ten years later, for about a year before his admission, twitching and flexion of the wrist, biceps, and deltoid, had been observed. Eight days before his admission he had received a blow on the right side of the head from a pair of tongs. Three days after this accident a convulsion on the right side of the body suddenly set in, beginning in the arm, then spreading to the face and leg, and followed by paralysis of the right side of the body. Repeated convulsions followed his admission. Mr. Harrison trephined the boy, *not* at the site of the last, but at the *site* of the *first* injury, and eventually evacuated four drachms of fetid pus, and the boy made an uninterrupted recovery. Macewen (loc. cit.) reports a remarkable case in which an acute abscess developed later in the periphery of an old encysted abscess. After evacuating several ounces of pus, the old abscess appeared "like a tennis-ball floating in a sea of pus." Wagner (loc. cit.) gives two cases of abscess arising seven and nine years respectively after falls without any external wound; and [illegible] reports one of abscess arising eleven years after a fracture of the skull.

If the injury is followed by meningitis, this will usually develop within three or four days; but should it result in abscess rather than in meningitis, it will not usually form earlier than at the end of the first week. The situation of an abscess after a blow or fall is almost invariably under the site of the injury, but, as is shown by Macewen's earliest case, Harrison's, and others, the location of the abscess must be fixed by considering not only the site of the injury, but the focal symptoms as shown by cerebral localization—*e.g.*, in Macewen's case the abscess was in Broca's [illegible], but the cicatrix was on the forehead.

Still another occasional cause is localized meningitis. Of this perhaps the most instructive case yet recorded is that found in the very able paper of Mr. A. E. Barker,[36] in which the pus, accumulating [illegible] between the island of Reil and the operculum, produced upward pressure on the motor centres for the face and arm. Complete recovery followed the operation.

Metastatic abscess occurs not infrequently in the brain as a result of various conditions, even in distant organs, such as gangrene of the lung, fetid bronchitis, and bronchiectasis. Tubercular abscesses, also, are sometimes seen, but in both these cases the abscesses are usually multiple, and hold out but little hope for any successful surgical treatment. Wernicke and Hahn and Fränkel have reported two cases of tubercular abscess which were single.

Symptoms.—The symptoms of cerebral abscess may be arranged in three categories. First. Those due to the suppurative process itself. Secondly. Symptoms arising from general pressure. Thirdly. Focal symptoms.

First: Among the symptoms arising from the suppurative process itself, the most important is fever, and it is especially noteworthy that the temperature is either normal or subnormal most of the time, even when the gravest cerebral symptoms exist. The temperature, however, does sometimes rise, especially towards the end, often attended by delirium, but will generally subside quickly, only to rise again after an interval if the patient survive long enough. V. Bergmann and others state, however, that the local cranial temperature in abscess will rise. If, therefore, symptoms of serious intracranial pressure exist, if the general temperature is normal or subnormal, while the local temperature shows a rise and the pulse is slow, the first thought of the surgeon should be to seek for evidence of abscess of the brain. A chill not uncommonly occurs, but may be absent. Of course, there will be loss of appetite, vomiting, general malaise, etc. [illegible] has stated that when pus is present in the brain, the chlorides in the urine will be below the norm and the phosphates above, but I know of no confirmatory examinations of this important assertion.

Secondly: Among the pressure symptoms, headache holds an important place. It is almost invariably present, and not uncommonly of an extreme and severe type, so that the patient will constantly moan ; and if he be sufficiently intelligent, this will be the one thing of which he will complain. It is apt to become worse, and when the temperature occasionally rises it is often located distinctly at the focus of the lesion, but sometimes is general. It does not, therefore, always serve as a guide to the situation of the abscess. The pulse is almost always slow, and may even fall to thirty or forty in the minute. Respiration is often of the Cheyne-Stokes type. The mental condition is very soon impaired, and gradually, as the pressure increases, becomes worse and worse until the patient may become comatose. Not seldom the bowels and bladder will be evacuated involuntarily. Convulsions of an epileptic type often occur, but not usually when the abscess is situated in the temporo-sphenoidal lobe. Sometimes convulsions will be the very first acute symptom. Muscular twitchings may occur, and if so, their occurrence will often point to the cortical centre involved. Sensation is not usually much impaired.

The presence or absence of choked disk does not seem to be pathognomonic, as it is sometimes present and sometimes absent. When present, even if bilateral, it is almost always more marked on the side of the lesion, though this is sometimes reversed. Not uncommonly there will be ptosis, and sometimes paralysis of the entire third nerve, while the sixth may escape ; though sometimes the reverse is the case. The pupil of the same side is generally dilated, and more or less immobile. Almost all the symptoms of pressure vary from time to time, and the patient's general condition fluctuates in a remarkable degree, sometimes simulating recovery, soon to relapse again into a worse state than before. Theoretically, there should probably be deafness of the opposite ear if the first or second temporal convolution is involved ; but this symptom is very uncertain.

When the abscess is situated in the cerebellum, the diagnosis is apt to be very obscure. Occipital headache and rigidity of the neck muscles often exist. Incoordination of movement, and especially an unsteady, drunken gait, indicates pressure upon the middle lobe. Vomiting and vertigo are frequent and persistent. If these symptoms exist with tenderness on pressure and pain on percussion over the cerebellum, they may point definitely to the cerebellum. Optic neuritis is not frequent in cerebellar abscess. But here, above all other localities, the remark of von Bergmann eminently applies : "The technique of the evacuation of brain abscess no longer deters us from operating. All progress in treatment must depend chiefly upon diagnosis." It is, therefore, especially important that all cases of brain abscess should be observed and reported with the minutest and most exact detail, especially if there is any suspicion of the cerebellum being involved, in order that we may learn how to make a more exact diagnosis.

At present the condition of the reflexes is not known with sufficient accuracy to be of much value in diagnosis, though they are probably increased on the side of the lesion. Their study is therefore all the more important, not only in abscess but in all other cranial lesions.

Thirdly : The symptoms by which the locality of an abscess may be inferred are chiefly those which are so admirably described in general by Dr. M. Allen Starr, in Vol. I. of this HANDBOOK, under the head of "Brain, Diagnosis of Local Lesions in the." I need, therefore, only briefly recall a few leading facts. The left temporo-sphenoidal lobe being adjacent to Broca's convolution, a very common result of abscess in this lobe would be motor aphasia. If the abscess is of such size as to press upon the inferior centres of the motor region, paralysis or paresis of the opposite side of the face would probably be first induced, followed by paralysis of the arm, and occasionally even complete hemiplegia of the opposite side. If the ear disease has implicated the seventh nerve in its passage from the petrous bone, there will be, of course, palsy of the same side of the face. Sometimes there will be a distinct squint from paralysis of the sixth nerve. Especially are all localizing symptoms valuable in those cases, which are not altogether rare, in which there is a suppurative discharge from *both* ears.

Mr. Barker has suggested that at the operation the mastoid foramen, through which passes a small vein to the lateral sinus, should be laid bare and an examination for pus be made. Should pus be found exuding from this foramen, it would certainly be a most valuable sign ; but thus far I do not know that its examination has proved to be of positive value. The foramen (Figs. 4873 and 4874, *i*) lies one and one fourth inch behind, and about one-fourth inch below, the external meatus, at the base of the mastoid process.

Should the abscess exist in the frontal lobe, as is sometimes the case from nasal disease, but little information can be derived from localizing symptoms, this lobe being a "latent" region. In the occipital lobe the same is true, unless the cuneus is involved, when hemianopsia on the same side of each retina would certainly follow. Should the angular or supramarginal gyrus be involved in the lesion, the state of the pupil may possibly give valuable information. In the *American Journal of the Medical Sciences* for October, 1888, pp. 349 and 355, Dr. Oliver has described a species of monocular Argyll-Robertson pupil, which seems to promise to be of value in lesions of this region.

The temperature of the two sides of the head should always be carefully taken, and in doing so it should be remembered that the left side is normally hotter than the right (Gray and Seguin, *Arch. Med.*, December, 1879). Should abnormal variation of the local temperature be observed, it would be a valuable indication, but one that as yet is not sufficient to localize an abscess with absolute certainty.

Percussion and pressure on the head are also valuable, but alone are not to be relied on absolutely. Taken with other symptoms, they may assist materially in the localization of an abscess. Hulke[40] records an instance of a tender spot above the ear in a case of abscess in the cerebellum ; and another of a tender spot over the occiput with an abscess in the temporo-sphenoidal lobe. Pain on *percussion*, but *not spontaneously complained of*, in the opinion of Ferrier, is of greater value than mere tenderness on pressure. Pressure and percussion are of value in diagnosticating cerebellar abscess from cerebral in many cases. Should the abscess, as occasionally happens, be extra-dural, its locality would almost certainly be indicated by œdema of the overlying scalp. This, therefore, should always be looked for.

Differential Diagnosis.—First, ***Meningitis :*** This is often a very difficult differential diagnosis. In meningitis there will usually be delirium, delusions, photophobia, contraction of the pupils, convulsive facial twitchings, high general temperature, and marked rigidity of the neck muscles, all developing rapidly after an injury or from disease of the ear, or in a strumous patient.

Secondly : ***Mastoid disease***, following purulent otitis media, sometimes gives rise to serious cerebral disturbance. Trephining the mastoid—which in nearly all cases of cerebral abscess, at least from ear disease, will precede the opening of the skull—will, in general, quickly differentiate this from intracranial abscess. As a rule, th emastoid region will be swollen, œdematous, and painful ; in other words, will present the usual evidences of mastoid disease. For the diagnosis from extra-dural abscess arising from mastoid disease, see p. 217.

Thirdly : *Thrombosis of the lateral sinuses and pyæmia* would most likely involve the internal and external jugular veins, into which, most probably, the thrombus would extend. They would be hard, cord-like, and painful, and the veins of the face would almost certainly be turgid and swollen. Besides this, very probably, there would be general symptoms of pyæmia, such as involvement of the joints, lungs, liver, etc. The axillary temperature also would never, as in abscess, be near or below the normal. There would almost certainly be rigors, profuse sweating, and great general prostration, without such marked dulling of the intellect as exists in abscess

Fourthly : *Tumor* While in most cases the diagnosis between abscess and tumor can be pretty clearly made, yet, in not a few cases, the diagnosis is difficult and sometimes impossible. Usually the development of a tumor is very slow, and is attended with distinct focal symptoms from the time when its existence is first manifested. While the development of abscess may be deferred in its outbreak, yet once started, it usually runs a much more rapid course than does tumor. Moreover, abscess has usually some evident cause, as recent injury, aural or nasal disease, etc. Tumor sometimes develops as a result of injury, but more commonly without. In tumor the optic neuritis is almost always double, and usually more intense than in the case of abscess. In abscess optic neuritis is much rarer, and if present, it is not rarely unilateral instead of bilateral, and may be on the side opposite to the abscess rather than on the same side (Gowers and Horsley's, Barker and Gowers's cases).

While tumor sometimes exists in the temporo-sphenoidal lobe or in the cerebellum, yet abscess is far more common in these situations. In other parts of the brain tumor is far more common than abscess. If syphilis exist as a cause, it is far more likely to give rise to tumor than to abscess. The temperature is not apt to rise in either case. Rapid and sharp fluctuations in the general condition of the patient would be more suggestive of abscess than of tumor; slow fluctuations are more common in tumor. Emaciation without sufficient cause sometimes attends abscess.

Surgical Treatment.—The almost uniform mortality that attends abscess of the brain, if not relieved, renders any means that holds out a reasonable prospect of relief a necessity. Very many such cases of abscess have been operated upon successfully by trephining, even so long ago as when Dupuytren and others boldly punctured the brain. So early as August, 1849, Detmold[4] even punctured the ventricle itself and evacuated an abscess, and Dr. George R. Morehouse, of Philadelphia, informs me that he did the same during the late Civil War. All this was done with boldness, it is true, but we must also add, that in the majority of cases it was rather the result of happy chance than of scientific precision.

The operation has entered upon an entirely new career since the establishment of the doctrines of cerebral localization. Abscesses in the brain, in the last few years, have been frequently and accurately localized, and successfully operated upon, by a number of surgeons.

When abscess from ear disease is suspected, the mastoid should, in most cases, first be trephined and carefully washed out. Should this operation not give relief, then we must proceed further and trephine the skull. But before this is done, the ear and mastoid should be most carefully cleansed with a bichloride solution and filled with powdered [illegible], in order to prevent any possible infection of the brain. The head should be shaved certainly over a large area, or better, entirely, and the scalp cleaned and disinfected in accordance with the method already described.

The question as to where the trephining shall be done is an important point. As already related, even in cases of abscesses arising from injury, the scar is not always over the point at which the abscess exists. It must be located by cerebral localization quite as much as by the site of the external lesion. Moreover, tenderness on pressure is not always a reliable indication of the site at which the trephining should be done, though tenderness on percussion is a more reliable sign.

In order to attack an abscess in the temporo-sphenoidal lobe two points are advocated. Mr. Caird,[5] who operated on Greenfield's case, applied the centre-pin of the trephine 1¼ inch behind the external angular process, and nearly one inch above the zygoma. This seems to me a very undesirable point, because it would generally strike the middle meningeal artery at or just below the antero-inferior angle of the parietal bone, where the artery not infrequently passes through a bony canal, and might give rise to hæmorrhage which would at least be troublesome.

A point ¾ of an inch in front of the meatus and 1¼ inch above Reid's "base line" was the spot I selected in a case of trephining for supposed cerebral abscess[6] for reasons there given. It is better than Mr. Caird's, I think, as it avoids the artery and even its posterior branch, and gives access to the temporo-sphenoidal lobe at about its middle; but the danger of wounding the middle cerebral artery, if the brain is incised or punctured, is possibly even a more serious objection. In certain other cases where the symptoms seem clearly to point in such a location, this point might, however, be selected with advantage.

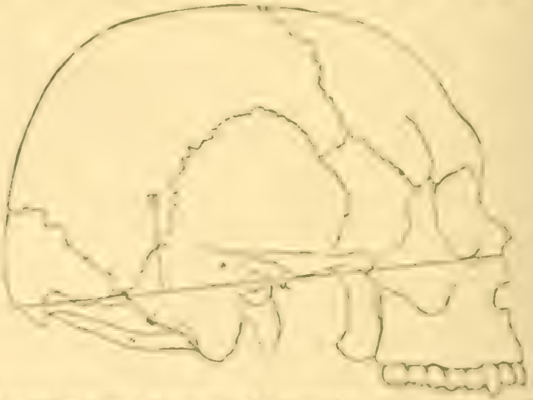

FIG. 873.—From a Photograph of a Cranium [illegible] Reid's "base line" running from the lower border of the orbit through the centre of the auditory meatus; x, the exact point at which the pin of the trephine was applied [illegible] cerebral abscess [illegible] the mastoid antrum [illegible] (Barker.)

In the majority of cases, however, I should agree with Mr. Barker[7] that the best place for trephining is 1¼ inch behind the external auditory meatus, and the same distance above Reid's "base line." (Figs. 873, x, and 874.) This is just above and behind the junction of the petrous with the squamous portions of the temporal bone. Even in children the distance above Reid's "base line" should be the same. I find that at a lower point the upper border of the petrous bone would greatly and suddenly thicken the inferior edge of the button of bone and might give some trouble in its removal. A director thrust downward, forward, and inward in the direction of the opposite ala of the nose, would pass through the axis of the temporo-sphenoidal lobe, and be almost certain to strike an abscess of any size. Should it fail to do so, punctures may be made in various other directions in order to reach possible small abscesses. As pointed out later, this same trephine opening can also be utilized for tapping the lateral ventricles, if necessary.

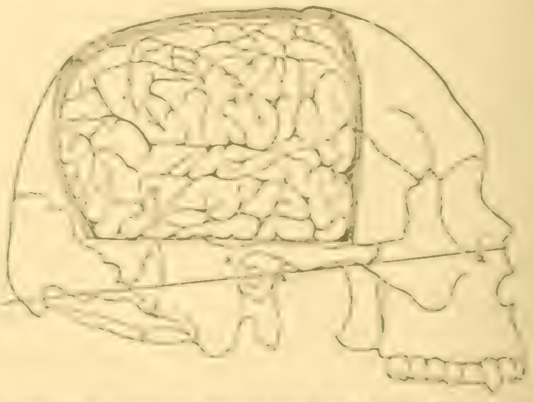

FIG. 874.—Photograph from the same Skull, with the Brain exposed in situ. The lettering is the same as in Fig. 873. [illegible] (Barker.)

In the report of the operation above alluded to, I have shown that repeated punctures may be made with a grooved director or hypodermic needle without any serious damage to the brain substance. I have there stated at some length my reasons for preferring the grooved director to either the knife or needle for *exploration* alone. A needle sucks up healthy brain tissue, even when the suction power does not exceed seven to ten minims, and the danger of wounding the vessels is not an imaginary one. With the director we feel much more safe, and will, therefore, be proportionally bolder and more thorough in our explorations. Such boldness and thoroughness, combined with safety, will often result in success, when timidity from possible danger would result in failure. In a recent case I punctured the frontal lobe four times with a director, and to the depth of 2½ inches, without any evil symptoms as a result. Rivington,[45] in 1881, was, I believe, the first to use the director boldly in this manner. He thrust it two inches into the brain. The remarkable paper of Spitzka[46] shows how freely we may puncture the brain without evil result. In many cases no trace of the puncture could be found, and where it existed there was only usually a trace of blood. Even the filthiest mud was injected into animals' brains, with but little damage as a rule.

For *incision*, however, as distinguished from *exploration*, the *knife* is certainly to be preferred. As soon, therefore, as the abscess cavity is reached the knife should be used, and then a pair of hæmostatic forceps be introduced, closed, and drawn out expanded to a reasonable degree, in order to afford free vent for the pus. Should the wall of the abscess cavity be lined with granulation tissue, it should be removed by the sharp spoon or otherwise, just as in case of an abscess in other parts of the body, care being taken not to encroach on any important neighboring centre or vessel. The abscess cavity may now be very gently washed out with weak bichloride or carbolic acid solution, and a rubber drainage-tube then be inserted. This should be passed through a good sized button-hole opening in the flap, and secured to the scalp by a long catgut thread tied in a bow-knot. The bone should not be replaced. If the first trephine opening does not afford good drainage a second should always be made in the proper place. An ample sublimate dressing should then be applied. The drainage-tube should be kept in place, but gradually shortened until the discharge has diminished to such an extent that it is safe to remove it. The catgut thread may be untied, secured to the tube, and retied at will. Even with the greatest care it will happen every now and then that the wound, after apparent healing, will have to be reopened to give vent to a reaccumulation of pus, as in a number of cases already reported. Thus McCutcheon[47] trephined his patient five times for as many different objects: 1, after the accident; 2, for compression; 3, for epilepsy; 4, for atrocious headaches; 5, for necrosed bone; each operation being followed by benefit, and the final one by recovery. Fenger and Lee[48] operated three times, Rivington[45] operated four times, and Schede[49] operated five times. All of these cases recovered. In Westmoreland's case[50] the blow was received in 1879, and repeated attacks of suppuration occurred in 1881, 1883, and 1886. In each case reopening the wound and redraining resulted in recovery.

Of course, if a fistula be discovered, even a small one, as in the case reported by Truckenbrodt,[51] and operated on by Schede, the trephine opening would be made at the site of the fistula rather than at any of the points above described, and would lead to the abscess. Weir[52] has suggested the injection of an aniline solution to discover the route and extent of the sinus.

If the abscess is in the cerebellum the proper place to trephine is well below the superior curved line, so as to avoid the lateral sinus, the centre-pin being placed midway between the tip of the mastoid process and the inion. A ¾-inch trephine or the chisel should be used. It must be remembered that the skull is quite thin and easily penetrated at this point. The opening can be enlarged later if necessary.

The flap in the dura should have its base upward. Of course, the occipital artery will have to be ligated. As pointed out by Weir,[52] "with the use of a spatula to lift it up slightly, the cerebellum can, if necessary, be viewed with an electric light nearly to the foramen magnum." With a grooved director or other appropriate means, the cerebellum can now be punctured and the abscess evacuated in a favorable position for drainage. Even should the abscess be upon the opposite side of the cerebellum, it would be easy, as I have shown, to reach it obliquely through such an opening. In making any puncture, however, care should be taken not to injure the superior vermiform process. A drainage-tube should be used and the abscess treated as before described.

If an abscess exists in any other place than in the temporo-sphenoidal lobe or in the cerebellum, the trephining should be done immediately over the site, as determined by cerebral localization, and the cavity treated as above described.

Should no abscess be found at the first trephine opening, and there is a possibility of its existence at another point, there is no objection to a second trephine opening, and even a third, should the necessity arise. The danger from an additional trephining is so slight, and the danger from abscess, if it exist, so great, that we should seek for it at a second or even a third place, if not found in the first. It is, however, scarcely necessary to add that this additional trephining should not be done without good and sufficient reasons. In such cases, when the abscess is found to be encysted, and encapsulated by a thick membrane, the membrane should, of course, be removed, as was done by Bergmann.

EXTRA-DURAL ABSCESSES.—Besides the abscesses in the substance of the brain, another variety exists that it is very important to recognize; that is, an abscess between the dura and the bones of the skull.

These almost always arise from ear disease by involvement of the bone and subsequent pachymeningitis externa followed by suppuration. The pus may accumulate in an abscess, or may be diffused between the dura and the skull.

Symptoms and Diagnosis.—They cannot be distinguished from cerebral abscesses proper, or from leptomeningitis or thrombosis of the lateral sinus, by the eye symptoms or headache, but other means may enable us to do so. The temperature, in marked contrast to cerebral abscess, will rise to 102°–104° F. The pain in extra-dural abscess is usually fixed either above or behind the ear, and is increased by percussion and pressure. The mastoid, of course, will be involved, but the tenderness on pressure or percussion will extend both further back and higher up than the mastoid. Usually there will be œdema of the overlying scalp. If the mastoid has already been opened and no improvement has followed, and no marked symptoms of the other cerebral diseases mentioned above be present, such as the pronounced cerebral irritative lesions of leptomeningitis, the localizing or focal symptoms and low temperature of cerebral abscess, or thrombosis of the internal jugular, and other signs of pyæmia in plugging of the lateral sinus, we should suspect extra-dural abscess. Pressure symptoms are rarely seen in extra-dural abscess, and especially if it arise from aural trouble. If evidence exist of caries of the bone, extra-dural abscess should be suspected, and especially if the pus well up through such a sinus and show any pulsation communicated from the brain. Not seldom a sequestrum or carious bone will be found.

Treatment.—The ordinary operation for trephining the mastoid will usually have been done for the earlier symptoms. If not, it should be done at once, and further operative procedure be carried out, if so indicated. If the operation be limited to opening of the mastoid, and this does not speedily bring relief, the skull itself should be opened either by the trephine or by the rongeur forceps. The probe or escaping pus will indicate to us any fistula, and this must be followed up till the carious or necrosed bone is discovered and the dura laid bare. This last can usually easily be recognized by its texture, relation to the bone, and its pulsation. Should the lateral sinus be exposed, care must be taken not to wound it. Should a thrombus exist in it, Horsley has suggested that it might be ligated and the clot evacuated. That recovery may take place after thrombosis of the sinus and without interfering with it, is shown by a case of Hoffmann. The abscess cavity having been reached, it should be cleaned out, the granulations from its walls removed, and free drainage provided, all carious or necrosed bone having, of course, been first removed. Unless such efficient operative measures be taken, the case is almost sure to prove fatal. Hoffmann, whose paper (loc. cit.) is the best study of the subject I have found, gives a statistic table of 107 fatal cases in which the diagnosis was established by a post-mortem examination, and its impressive lesson is but reinforced by the 10 additional cases diagnosticated during life. Four of these were reported by others, of which 2 recovered after operation; 6 are reported by himself, of which 5 recovered after operation, one dying six weeks later from bronchitis. No other commentary as to the absolute necessity for an operation can be needed. The causes of death were usually meningitis, cerebral abscess, and pyæmia, with and probably from thrombosis of the lateral sinus.

INTRACRANIAL TUMORS.—The causes of intracranial growths are various, but in the majority of cases the cause can scarcely be ascertained. Injury occasionally plays an important rôle, but much more frequently they arise without any apparent local cause. The statistics of Hale White and Bernhardt, quoted by Seguin and Weir, give a sufficient number of cases to draw approximately correct conclusions from. They number 580, and are as follows:

	Number.	Per cent.
Nature of tumor not stated	[illegible]	[illegible]
Tubercular tumors	157	[illegible]
[illegible]	76	[illegible]
[illegible]	75	[illegible]
Hydatids, cysticerci, and echinococci	30	[illegible]
Cysts	27	4.6
[illegible]	24	[illegible]
[illegible]	21	3.6
[illegible]	14	[illegible]
[illegible]	12	[illegible]
[illegible]	6	[illegible]
[illegible]	4	[illegible]
[illegible]	4	[illegible]
[illegible]	4	[illegible]
[illegible]	3	
[illegible]	2	
[illegible]	2	
[illegible]	2	
[illegible]	2	
[illegible]	1	
[illegible]	1	
Total	580	

This shows that tubercle is nearly twice as common as any other one known cause. Tubercular tumors are most frequent in early life, three-fourths of them occurring before twenty, and one-half before ten years of age (Gowers). The various forms of cancer, including sarcoma, would exceed even tubercle as a cause. They are most common from twenty to forty. Other causes, excepting hydatids and cysts, furnish each but a small number. The small percentage of syphilitic gummata is rather surprising. Dr. Gowers states that of 637 intracranial tumors the distribution was as follows: Cerebral hemispheres (excluding the central ganglia), 297; cerebellum, 170; pons, 49; central ganglia, 48; meninges, 31; corp. quad., 18; crura cerebri, 10. Starr, in a valuable paper on 300 cases of intracranial tumors in children, found 98 in the cerebellum.

The symptoms have been so carefully studied and so fully treated by Dr. Mary Putnam Jacobi, in the first volume of this HANDBOOK (article on Brain Tumors, etc.), and by Dr. M. Allen Starr, in an article in the same volume (p. 642) on Localized Lesions of the Brain, that it would be but a repetition here for me to consider them. Three points, however, ought to be more fully noticed, viz., disturbance of language, eye symptoms, and local temperature.

The most important paper lately published in connection with disturbances of language is that by Dr. M. Allen Starr. Words in ordinary use have a complex mental substratum, made up of a number of mental pictures. These are: first, memory of the sound of a word as spoken; if this be lost we have "word deafness." Second, memory of the appearance of a word as printed or written; if this be lost we have "word blindness." Third, memory of the muscular movements made in writing a word; if this be lost the result is "agraphia," or inability to write. Fourth, memory of the muscular movements made in pronouncing a word; if this be lost, although the vocal apparatus is perfect, it is known as "motor aphasia." Fifth, the word-hearing and word-uttering processes may be perfect, and the patient can understand what is said to him, and can pronounce words well, but the connection between the word-hearing and the word-uttering processes is broken, and the patient misplaces words or uses one word for another—for instance, calling the "[illegible]" the "[illegible]." This is known as "paraphasia," or the aphasia of conduction of Wernicke. The lesion in these cases usually involves the island of Reil and severs the fibres beneath it, the great association tract uniting the temporal and frontal lobes with one another. Sixth, the mind may not recognize the use, name, color, form, etc., of any object presented to it. This general symptom is termed "apraxia." It has, of necessity, as many varieties as there are avenues by which the mind may be reached, for instance, by sight, smell, taste, hearing (not only hearing for language, but for music), either of which may be lost separately, thus producing "mind blindness," "mind deafness," etc. The patient, however, though unable to recognize any object when seen, may be able to do so when *felt*. These symptoms (according to Starr) are only found when the lesion is in the left hemisphere in a right-handed person, and in the right hemisphere in a left-handed person. Hence, in examining an aphasic thoroughly, Starr states that it is necessary to test: first, the power to recall the spoken or written name of an object seen, heard, touched, tasted, or smelt. Second, the power to understand speech, and also music. Third, the power to understand printed or written words. Fourth, the power to speak voluntarily. Does he talk clearly? Does he mispronounce words or talk jargon? Fifth, the power to repeat words when dictated. Sixth, the power to read aloud. Does he understand what he reads? Seventh, the power to write voluntarily. Can he read what he has written? Eighth, the power to write at dictation. Ninth, the power to copy. Tenth, the power to recognize the use of objects seen, felt, heard, tasted, or smelled. One illustration, and only one, so far as I know, exists of the diagnosis of a lesion by the existence of "mind blindness," and this was followed by a brilliant and successful treatment. This is recorded by Macewen, and is briefly quoted on p. 228 of this article.

Eye Symptoms.—These have been, and in fact are still being, most carefully studied by Dr. Charles A. Oliver and myself in every case of cerebral disease presented to us. The full consideration of this must necessarily be delayed until we have sufficient material to study and from which to draw more accurate conclusions. This will be done by Dr. Oliver in a future paper. At present, however, we may make the following statements, together with a short description of the methods of examination, not only in tumor but other disorders of the brain.

When it is remembered that the second, the third, the fourth, and the sixth nerves, in their entirety, are solely intended for innervation and special functions of the organ of vision, it will be readily understood how important this apparatus becomes as an index of intracranial disturbance.

The methods may be briefly given in a series of short captions, as follows:

1. Always, if possible, get central vision in each eye separately, not only for form but for color, as this practically gives the physiological power of the most highly evolutionized fibres of each retina. Types, the smallest known sizes of types or symbols, and graded areas of definite colors, such as green, red, rose, blue, and yellow, should be placed at certain distances in good light, and the results compared with the normal standards for each

distances. Should the patient be unable to designate types, symbols, or colors, then keys, coins, etc., of the same size as certain test letters can be held at the related distances, or less if necessary, and attempts made for similar selection among duplicates held in the lap.

2. *Power and range of accommodation* should be tried separately and combinedly for the smallest type visible, with or without helping lenses, at the nearest, furthest, and best points possible. Retinoscopy may be useful in quite a number of cases. Tonic and clonic spasm must be sought for.

3. *Visual fields* must be most carefully studied, not only in reference to comparative sizes and areas for white, yellow, blue, red, and green; but blind spots and points of feeble color saturation must be diligently sought for and noted.

4. More complete study of *central color perception* should now be made with graded intensities of Holmgren's wools, and the results should be recorded upon suitable blanks.

5. The *pupils* should be examined and re-examined separately and in associated action, until definite answers can be given as to their comparative sizes and shapes.

6. Monocular and binocular *action of the irides* to light stimulus thrown from all parts of the visual field; to associated action with the ciliary muscles, as in accommodative efforts; and to the combined and associated action with the ciliary muscles and internal rectus muscles, as in convergence, must be repeated over and over until unequivocal results are obtained. Spasmodic action of the irides must be carefully looked for.

7. *Extra-ocular muscle balance*, when the organs are in a state of rest, should be obtained as correctly as possible.

8. Combined and disassociated *action of the attached extra-ocular muscles* in convergence, conjugate deviation, extreme separate and combined excursions in all directions, must be gone over with special study of the varying degrees of change from the slightest loss of innervation up to total paralysis. Search for clonic and tonic spasms should also be carefully made.

9. Combined and associated *action of the muscular apparatus of the ocular appendages* should now follow, in reference both to paretic and spasmodic changes.

10. *Sensibility of the entire ocular superficies*, both to touch and pain, should be studied.

11. In cases in which a difference of temperatures is suspected, *comparative surface thermometry* should be made, although it is really best not to omit it in any instance.

12. Accurate *ophthalmoscopic study* of the media and the fundus of each eye should be repeatedly made, until adequate data as to the comparative condition of the two organs are correctly obtained.

Having thus obtained this grouping of ocular conditions in association with the history and concomitant symptoms, determinations can often be made of sufficient accuracy to point out at least not only the probable character of the lesion, but even its possible situation. Negative signs may ofttimes prove themselves of great value in the diagnosis of the position of the supposed growth; and no case can be said to be complete and ready for surgical procedure until all the ocular changes have been properly and carefully studied.

For the purposes of help in differential diagnosis the few following general observations, which for the present must necessarily remain *sub judice*, may be of use to the reader:

Optic neuritis is very usual in some stage of intracranial tumor, and indicates more rapid progress of the growth. It is of no definite value in the diagnosis of the position, the character, and the size of the mass.

If the so-called monocular type be met with in such cases, the neoplasm is most probably situated in the opposite hemisphere; and should the neuritis be double (*which is most probably always the case*), it is almost certain that the side of the lesser optic nerve swelling is the one in which to look for the growth. The occurrence of this symptom is less frequent in abscess, and may be more ordinarily found upon the same side as that of the lesion than in tumor. It seldom occurs, if at all, in cortical lesions with irritative symptoms

Primary optic nerve atrophy with or without retinal change, as shown by the ophthalmoscope, is generally found in connection with basilar disease or trunkal inflammation, from trauma, new growths, general dyscrasia, and the introduction of toxic agents into the system. In epilepsy it is seldom decidedly marked, being usually found in its incipient form, and seemingly dependent upon the number and severity of the seizures. It is not apt to occur in abscess, except in those rare cases of the encysted and slowly growing varieties.

Weakening of any single muscle, or any group of muscles, generally indicates either pressure from a coarse lesion, external to any portion of the related outgoing fibres, or true infiltration of pathogenic material into the neural meshes themselves. Unassociated with other symptoms it is of little value in questions of the position of the lesion, and must be used in conjunction with other data to be of any determining use. Being, however, more of a fixed quantity than muscle irritation, it is of greater importance in such instances than the latter, as it better shows the probable position of the lesion. Localized spasm in itself is probably more apt to be caused by lesions in the motor zones and in the centres devoted to the action of the involved group or groups of muscles. It thus often offers itself of special diagnostic value in the localization of the initial point of the epileptic spasm.

In acute and subacute meningitis, irritative symptoms of both motor and sensory varieties appear, whereas, in the chronic form, degenerative changes are more prone to occur.

Hemianopsia is of paramount importance, more so than aphasia and agraphia. Each variety, carefully considered in conjunction with ophthalmoscopic study, experiments with pupillary responses, and other motor and sensory disturbances, can hardly fail to serve as most important data for indicating the probable situation of the lesion.

It must be remembered, however, that each ocular symptom in itself, is not etiologically self-answerable. Careful study must be made of all the conditions, so that, by the process of exclusion, adequate data can be obtained upon which to base answers as to the character, the type, and the situation of the supposed intracranial lesion.

Surface Temperature of the Head.—Mills and Lloyd, in Pepper's "System of Medicine," vol. v., p. 1036, have given the record of four cases of tumor of the cerebrum and one of the cerebellum. Seguin and Weir (*loc. cit.*) have recorded the temperatures in their case, and I have done the same in the case of tumor in my first paper already referred to. The general conclusion seems to be that the average temperature of the whole head is elevated somewhat above the normal, and that the elevation of temperature is usually greatest at the station nearest to the site of the growth. But a much larger number of observations must be made in order to reach a definite conclusion as to this symptom; therefore, every case of supposed tumor, and, in fact, every other lesion in the skull, should have the surface temperatures carefully noted both before and after the operation, if any be done. In the second case in my paper the temperature certainly seemed to be elevated by the irritation of the lesion present. The elevation immediately disappeared after the operation, coincidently with the cessation of the epileptic attacks. In the third case in which the fits were relieved, but not cured, the temperature did not fall. Our surface thermometers also are as yet much lacking in accuracy, as they are used in practice.

Diagnosis.—While in many cases the diagnosis is sufficiently clear, in others we are, of necessity, in the greatest doubt, until the operation, it may be, reveals the correctness or the incorrectness of our conclusions. Hence, as already quoted with approval from von Bergmann, the great necessity of a correct diagnosis on the part of the neurologist, so that the surgeon may be sure that his attempt to remove a supposed tumor will not cause chagrin to both by finding none. This has occurred in several instances.

In the careful and elaborate paper of Seguin and Weir, already referred to. It is pointed out that the diagnosis before operation must be worked out in five lines of inquiry. 1. The existence of tumor. 2. Its exact location. 3. Whether it is cortical or subcortical. 4. Whether solitary or multiple. 5. Its nature; to which I would add: 6. If possible, its size.

1. *Diagnosis of the Existence of a Tumor.*—When the symptoms referred to by Dr. Jacobi, in his article on tumors, such as headache, gradually developing optic neuritis, convulsions, either general or localized, paralysis in varying degrees (indeed these sometimes hemianopsia), slow pulse, probably localized rise of temperature with vomiting, etc., are present, and in some cases with but little modification, it is almost certain that we have a tumor. The more difficult diagnosis is often between tumor and abscess, and for their differential diagnosis I must refer the reader to the section on abscess of the brain (p. 216).

2. *Diagnosis of the Location of the Tumor.*—This must be done chiefly by the localizing symptoms. In certain parts of the brain a tumor may exist and give rise to no localizing symptoms, but only to general headache, choked disk, convulsions, etc. This is more particularly in the anterior portion of the frontal lobes, in the temporo-sphenoidal lobes, especially on the right side, and in parts of the parietal and occipital lobes. But gradually these "latent areas" are being narrowed progressively to smaller and smaller portions of the cerebrum. It is not too much to hope that eventually there may be no "latent areas." The reader must refer to that portion of this article which treats of Topography of the Brain, and to Dr. Jacobi's and Dr. Starr's papers in the first volume of this Handbook, for the details of the methods of localization, whether in the motor or in the sensory areas. One point must be regarded in following the history of a case. If a tumor increase in size, centres adjacent to the first one involved will also be affected; hence a succession of additional spasms and of pareses will develop in different parts of the body, and they are very important to study. The first localized spasm or paresis Seguin has proposed to call the "signal symptom," a happy name for so important a symptom in diagnosis. Rapidly produced blindness, as pointed out by Zenner and others, is usually due to tumors (especially in the cerebellum) which obstruct the veins of Galen or the straight sinus, and so produce internal (ventricular) hydrocephalus and pressure on the optic tracts, followed by choked disc and hemorrhages.

3. *The Diagnosis of the Depth at which a Tumor lies, i.e., whether Cortical or Subcortical.*—Seguin, in the article already quoted, concludes that a tumor of the cortex cannot be distinguished from a subcortical tumor by the character of the convulsions or by the presence or absence of localized headache, or by the cranial temperature. But tenderness on percussion rather than pressure may very possibly be of some service. In this as in the question of local temperatures, it must be urged that more exact and detailed clinical histories may hereafter give us the means of making such a diagnosis. How near one may come to touching a tumor and yet miss it, is well shown in a case of Seeds' in which he recognized unusual resistance in two punctures by the needle, yet did not remove the growth, which was found at the autopsy just below the surface. Surgery had not then reached its present boldness and success.

4. *Is the Tumor Solitary or Multiple?*—If solitary, it may be successfully attacked by operation, but if multiple it would be clearly unadvisable in most cases, unless the multiple tumors are grouped within a limited area. If single, the localizing symptoms will probably point to one area alone if the tumor be small, or if large, several areas may be involved; but these areas will be adjacent to the primary one. If, however, localizing symptoms give two or more centres far apart, without any intervening centres being involved, then the multiplicity of the growth is probable.

5. *The Diagnosis of the Nature of the Tumor.*—In some cases this may be made with fair approach to accuracy. For example, if the patient has cancer, tubercle, or syphilis in other organs, and shows characteristic symptoms of intracranial tumor, it will most likely be of the same type as the disease in the other part of the body. Beyond these three classes of tumor I do not think it possible to make other than a guess at its nature.

Hale White and von Bergmann are both opposed to operation in case the nature of the tumor is probably syphilitic. I quite agree with Seguin, however, that, provided thorough antisyphilitic treatment has been ineffectual, including the American method of the administration of large and increasing doses of iodides, if possible up to half an ounce a day, the probable gummatous character of the tumor or syphilitic disease of the bones or membranes, is not a bar to operation. Once that a gumma has become organized and permanently developed, and has resisted vigorous specific treatment, it should be attacked precisely as any other tumor would be dealt with, surgically, unless contraindicated by special symptoms, such as multiplicity, etc.

6. *The Size of the Tumor.*—This in a few cases can be probably diagnosticated. The diagnosis of a small tumor will be based upon its involving a restricted area of representation in the brain, as shown by the limited portion of the body involved; by the non-progressive involvement of neighboring centres; and by the absence of marked pressure symptoms. A large tumor will involve a large number of neighboring centres and would show marked pressure symptoms. Until the operation, however, it is impossible to make any accurate diagnosis of the size of a tumor. It is probable, however, that a few of them will be so large (F. A. Heath) as to prohibit surgical interference, before the general symptoms will be so grave as to make such interference quite unadvisable.

Surgical Treatment of Intracranial Tumors.—I have already referred to the historical case of Bennett and Godlee, which was the first really to arouse the attention of the surgical world to the possible diagnostication and removal of a brain tumor, of which there were no external local symptoms. I have also referred to later cases which have been operated upon, and which have made such a brilliant chapter in cerebral surgery—a chapter that has only been begun, the end of which we cannot even yet see. But we know enough to be sure that the beneficent results will be much wider and more important than we now expect. Operations have been undertaken by Weir, Hammond, and Gerster, in which no tumor has been found. But in Weir's case, at least, the exploratory operation was followed by great improvement, probably in consequence of the relief obtained from intracranial pressure. In Mr. F. A. Heath's case, though a tumor was found, its adhesions were so extensive in the anterior fossa that it could not be removed; but here again the great relief, in spite of hernia cerebri, was marked. The limits of operative interference with cerebral tumor are not, of course, at all well defined. Mr. Horsley has pointed out that a tumor situated in the auditory nerve, as was discovered at the post mortem, could have been removed by incising the tentorium. Weir has pointed out that by detaching the dura, the lateral or longitudinal sinuses can be lifted out of the way, a procedure which I have found also perfectly practicable.

As to operative technique I have already taken up the various steps under that head. The only point necessary to be insisted upon here is, that in cases of tumor which are not encapsulated, it is not only important that the entire tumor shall be removed, but also the zone of apparently healthy but probably infiltrated brain tissue in its immediate vicinity, so that we may be sure, so far as it is possible, that we have removed the entire neoplasm. In doing so the surgeon must remember that he can excise with greater impunity a larger area in the antero-posterior direction than in the vertical, for reasons already given.

Prognosis.—In case the tumor is malignant, its return is only a question of time. In Weir and Seguin's case of sarcoma the patient was alive about a year after the operation, but with symptoms of beginning recurrence. In tubercular and syphilitic tumor the prognosis is, of course, a much more favorable one; while in cases of benign growths, such as my own (a fibroma), recurrence is not to be expected. It is proper to add that in my own case there have been a few recurrences of epileptic fits. What the ultimate physical and mental condition of a patient will be after the removal of a cerebral tumor, the data are as yet too small for a definite statement, but the results (especially in Macewen's and in Horsley's cases) have been most encouraging.

The prognosis as to death or recovery from such operation cannot be made in any individual case, for up to the time of the operation we cannot be certain of the size and the relations of such tumor, nor of the surgical complications that may arise during its removal.

The *percentage of recovery* in cases of operation on intracranial tumors has been, for a new operation, unexpectedly large. In general it can be stated that the mortality at present is only 35.3 per cent. Of course, in any individual case, it will depend largely on the size, position, complications, etc. Undoubtedly, in the future, we shall have much better results when we learn, first, what cases ought and what ought not to be attacked, and secondly, when we improve the technique. Thus far, seventeen operations on intracranial tumor have been reported, of which eleven have recovered and six died. The following table gives all the cases thus far recorded :

Cases.	Operators.	Reference.	Result.
I.	Macewen	Glasgow Medical Journal, 1879, vol. xii., p. 210.	Recovered.
II.	Bennett and Godlee.	Lancet, December 20, 1884.	Died twenty-sixth day, meningitis.
III.	Hirschfelder and Morse.	Pacific Medical and Surgical Journal, April, 1886.	Died seventh day, encephalitis.
IV.	Bennet May....	Lancet, April 16, 1887.	Died in three hours.
V.	Weir and Birdsall.	Medical News, April 16, 1887.	Died next day, hæmorrhage.
VI.	Horsley and Ferrier.	British Medical Journal, April 23, 1887.	Recovered.
VII.	Horsley and Ferrier.	British Medical Journal, April 23, 1887.	Recovered.
VIII.	Horsley and Bastian.	British Medical Journal, April 23, 1887.	Died in nineteen hours.
IX.	Suckling........	Lancet, October 1, 1887.	Died second day.
X.	Durante.	Lancet, October 1, 1887.	Recovered.
XI.	Markoe....	Medical News, November 5, 1887.	Recovered.
XII.	Heath..........	Lancet, April, 7, 1888.	Tumor not removed. Recovered.
XIII	Horsley, quoted by Harrison.	Liverpool Medico-Chirurgical Journal, July, 1888.	Recovered.
XIV.	Weir and Seguin.	American Journal of the Medical Sciences, July to September, 1888.	Recovered.
XV.	Macewen	British Medical Journal, August 11, 1888.	Lived eight years.
XVI.	Macewen	British Medical Journal, August 11, 1888, p. 307.	Recovered. Tumor not removed.
XVII.	Keen...........	American Journal of the Medical Sciences, October and November, 1888.	Recovered.

It is not unworthy of notice that of the 17 cases 3 have been tumors of the cerebellum, and that all three died (Nos. IV., VIII., and IX.). Whether this mortality is merely incidental, or whether operations on tumors of the cerebellum are, as is probable, more fatal *per se*, cannot as yet be definitely determined, but it is a fact not to be overlooked. The mortality of cerebral as distinguished from cerebellar tumors has only been 3 in 14 cases, or 21.4 per cent. Weir and Seguin's case has shown symptoms of recurrence after nearly a year, and will probably soon die. One of Horsley and Ferrier's cases (No. VI.) died after six months, from recurrence. Counting these as fatal cases, the ultimate mortality has been only 35.7 per cent.

Case XIII. (Horsley's) was one of ivory exostosis at the root of the orbit, giving rise to paralysis and convulsions, and though not pathologically a cerebral tumor, was equivalent to it surgically.

Two of the cases (XII., XVI.) were of such a character that the tumors were not removed.

Epilepsy.—From a surgical point of view cases of epilepsy may be sharply divided into the traumatic and the non-traumatic varieties. The cases arising from traumatism can again be subdivided into (1) those in which the scar, old depression, etc., arising from injury, lies over well recognized centres, motor or otherwise, and (2) those in which the evidences of injury lie over the so-called "latent zones" in the brain.

In those cases in which the lesion lies over well known centres, and the epileptic fits affect only the muscles corresponding to the motor centres (monospasm or hemispasm) there can be no question at present as to the propriety of surgical interference, and the excision of the epileptogenous centre so involved. In the cases where the injury lies over a portion of the "latent zones," I believe that it is also proper to operate. Accumulated experience, however, will be needed to decide these questions absolutely. While these are my present opinions, I would not assert them too emphatically.

In these traumatic cases it is always possible that the scalp may be the site of irritation, and should there at least be no evidence of depression of the skull, it would always be wise, therefore, to *excise the scar* first of all, especially if it be tender, or if pressure upon it produces pain or an epileptic fit, or if the epileptic aura starts from the scar. Even should none of these symptoms be present, and if the bone be not fractured, I should deem it right first to excise the scar and then to wait in order to see whether this would cut short the epileptic seizures. Thus Briggs reports five such cases and Mears one in which such a happy result followed mere excision of the scars. Any other source of peripheral irritation must also be eliminated, as has long since been observed. Briggs relates a case in point in the same paper (p. 115), in which a girl had both a depressed cranial fracture and necrosis of the tibia. He wisely operated on the tibia first to eliminate this as a source of irritation, and the fits had not recurred when the case was reported five years later, thus disproving their origin from the fracture of the skull, which was *prima facie* the most probable cause. It must be remembered, also, that *any* operation is apt to cause a cessation of the fits for some time ; hence, before deciding that the epilepsy has been cured by removal of the scar or other source of irritation, at least two or three years of immunity should elapse. Should excision of the scar not cure the patient, or should there be a depression of the skull, with fits corresponding in their distribution to the motor centre or centres over which the scar lies, the patient should be trephined. The operator will probably find a splintering of the inner table, with not uncommonly a fragment of bone either detached or projecting into the brain substance. Sometimes a cyst will have been developed under the site of the injury. Sometimes, as a result of laceration of the brain tissue at the time of the injury, a brain scar will be found. The dura, also, will have been ruptured in some cases, and a scar will be found in it, or mere eburnation of the bones, as a result of osteitis from the traumatism, may be the only lesion. The skull having been trephined and the dura opened, the damaged brain tissue should be removed, and if there be a scar or thickening of the dura, the dura itself should be removed. In removing the damaged brain tissue, care must be taken to see that it is *all* removed, even to the extent of trenching upon apparently healthy brain tissue, and the directions heretofore given that freer excision may be made in the antero-posterior direction than in the vertical (for reasons already mentioned) must be remembered. The bone should not be replaced in a large piece, if by its shape, or for any other reason, it would cause pressure on the brain. It may sometimes be replaced to advantage after dividing it into small pieces by the chisel or rongeur forceps.

In those cases in which the lesion lies over the "latent zones," the same rule would apply to the excision of the cutaneous scar as above given. Should this not effect a cure, then it would be proper to operate. What should be done would depend upon what was found to exist in the brain, and any damaged brain tissue or cyst should be excised as above. Occasionally, after accidents, primary trephining will have been done, yet epilepsy will develop at a longer or shorter time after healing. In such cases, no matter where situated, it is sometimes wise to raise the flap over the site of the primary trephining and round off the edges of the bone, and to excise any scar in the dura or in the brain which may have resulted from the primary traumatism or from any operation done at that time. The question, however, of secondary operation is still undecided. Our experience as yet is not wide enough to dogmatize.

The papers of Macewen and Horsley may at present be accepted to be the best illustrations of the treatment above described, as well for the traumatic as for the non-traumatic cases still to be considered.

Non-traumatic Epilepsy.—First, of the Jacksonian type. So far as our limited experience goes, it seems probable that in cases of distinct Jacksonian epilepsy it is proper to operate and to excise the centre corresponding to that portion of the body which is involved. The experience of Horsley and Macewen, as well as quite a number of other operators, at present would seem to show that such operations at least do no harm, and in not a few cases they have resulted in apparent recovery both from the epilepsy and from the operation. It is a matter of some importance also that, if we operate at all, it shall be as early as possible, before the "epileptic habit" has been established. But both in this and in the non-Jacksonian type, *it is of the utmost importance that the fits shall have been always observed by a competent, and, if possible, a trained observer.* I have already had brought to me for operation a number of cases of alleged Jacksonian epilepsy and others of ordinary epileptic type, in which the fits were said to be limited and uniform in the point of beginning. These statements have been in some cases the result of the patient's knowledge, but more commonly of members of the family only. It is very evident that persons not trained to exact observation, and especially those persons whose affections are involved, and whose first motive would be to aid the patient rather than to observe the fit, are, as a rule, incompetent observers. Several times after placing such persons in hospital under observation I have found that the fits had not been at all correctly described. Therefore it cannot be too strongly insisted upon that accurate observations shall be made the foundation of knowledge before we proceed to excise any brain centre. In making these observations not only should the observer note all the phenomena in detail, and especially the muscles involved—particularly the muscle or muscles first involved (Seguin's "signal symptom") and the "march" of the fit (that is, the progressive involvement of one muscle or set of muscles after another); but the dynamometer should be used as soon as possible after the fit to determine whether the muscles involved in the fit be paretic.

Secondly.—In cases of general epilepsy, there have been reported already several cases of excision of the centre in which apparently the convulsion starts (Seguin's "signal symptom"). The results thus far may be said to be fairly satisfactory. In a number of cases there has been no return of the fits after some weeks or months; or the fits have been diminished in number or ameliorated in type, passing from attacks of severe convulsions into slight petit mal. It is as yet, however, far too early in the history of cerebral surgery, in my opinion, to decide positively whether it will prove wise to excise such a centre or not. Several years must elapse, and the definite later history of the patients be published, and in sufficient numbers, before any definite conclusion can be reached. Meanwhile, in any suitable case where the fits have been accurately observed, it would seem to be proper at present to excise such centres for the discharging lesion, not operating indiscriminately, but only in well-selected cases. Mr. Macewen has objected seriously to such operations on the ground of subsequent paralysis. This seems to me not to be a valid objection. To exchange epilepsy for paralysis would, I think, be a choice at which few patients would hesitate. It must also be remembered that the excision of a centre for an ordinary group of muscles, though it be followed by paralysis which may even be complete, has resulted eventually in so great a restoration of power as to convert the paralysis to merely moderate paresis, probably through the compensative action of the centre on the opposite side. Thus, in the third case related in my first paper already referred to, in which excision of the wrist centre was done, the patient was entirely paralyzed from May 31, 1888, till early in July. Motion began to return at this time, and when I last saw him, in the middle of September, 1888, he had so far regained control of his hand as to be able to play base-ball. The fits, however, had persisted, though changed in type, there being now but few severe convulsions and only a moderate number of attacks of petit mal.

As to operative procedure in these cases, it is important, first of all, to obtain a view of the brain sufficiently large for the operator to be able to recognize the convolutions. Once the convolutions are exposed, no antiseptic solution should be allowed to touch them until the centre sought for shall have been well defined by the battery. Hot water, however, may be used to check the bleeding. As soon as the brain is uncovered the faradic current should be employed by means of my double electrode (Fig. 458, p. 217).

In common with Nancrede and other operators, I have been very much struck with the strength of the current required to cause muscular contraction. I have found it necessary to use a current so strong as to be painful to my hand before any muscular response was obtained from faradizing the brain. Nancrede has questioned whether this may not be a serious injury to the brain. It does not at least seem to have been, but it is sufficiently possible to make us faradize the brain as little as is possible consistent with accomplishing our purpose.

When any centre sought for has been found I have suggested that a little nick be made in it, in order that it may be recognized again without difficulty. As this nick would be in the part of the centre to be removed, it would do no harm. As above described, all the centre, and possibly even a little more, should be excised in order that we may be sure of the thoroughness of our work. As Horsley has stated, most of the reported failures are due to too limited an excision.

The remainder of the operative procedure is as described in the section on the technique.

INJURIES OF THE HEAD. *Contusion.*—In any case of serious contusion, the patient should at once be put to bed on light diet, and the bowels and general hygiene carefully looked to. The patient should then be closely watched, and if any serious symptoms arise indicating intracranial mischief, a semicircular flap of the scalp should be raised and the bone inspected. If a fracture of the bone be discovered and the symptoms are at all serious, showing that inflammation of the meninges or of the brain substance has set in or is impending, exploratory trephining must be done at once, and the dura be opened. Even if no fracture exists, if the symptoms are those of encephalitis, trephining should be done. It is possible, in such a case, either that a piece of the inner table has been separated, with or without external fracture, or that the dura has been ruptured or the brain lacerated, and that inflammation with exudation has begun. Once inflammation with its attending proliferation has set in, it is essential that a means of escape for exudation be provided for, or for the escape of pus if the inflammation shall have proceeded so far. In other words, we should treat contusions followed by serious symptoms of mischief in precisely the same manner that we would treat them in any other part of the body, always remembering that in the brain it is impossible for any exudation or hæmorrhage to find its way to the surface without surgical assistance, by reason of the bony case in which it is contained. Trephining of the skull, therefore, is only equivalent to incision through the soft parts down to the seat of injury in any other part of the body. In many cases of very severe contusion, it would be proper immediately to make a horseshoe flap in order to determine the question of fracture. The swelling of the scalp is often so thick and so dense that in some cases it is extremely difficult to ascertain whether a fracture exists or not without such an incision. It is all important to know this fact, and especially if there be depression or not, so that the proper treatment shall be adopted. *Preventive* *trephining*, in many of these cases, is not only justifiable but demanded. A simple incision through the scalp is of itself unattended with danger in these days of antiseptic surgery. It may be objected that if a simple fracture exists, by such an incision we convert it into a compound one; but the position taken by Roberts in 1885 is certainly the correct one, that such an incision, with modern surgical methods, adds nothing to the danger, and is the only method by which we can make an absolutely certain diagnosis in any serious case, and so enable us to pursue a course of treatment which will diminish or avoid the danger.

Should there be any motor paralysis without any decided loss of sensation, there is almost certainly a lesion of the cortex; but, as Ferrier has pointed out, if sensation is impaired to any extent, there is probably a lesion of the sensory tracts of the internal capsule, or of the centres to which they are distributed.

Even after recovery from a severe contusion of the head, the patient should be carefully watched for some months, as in not a few instances abscesses, cysts, or epilepsy has developed after a long time. One case in which I trephined, a month after an exploratory incision of the scalp alone had been made, was most instructive as to the intracranial effects of a very slight extracranial traumatism. In enlarging the trephine-opening, I found that the dura suddenly became remarkably adherent to the bone. Inspection showed me that the area of adhesion was precisely under the flap of the first operation. This had been simply the raising of a flap of scalp, had been conducted with the utmost antiseptic care, and had healed without incident in a few days; yet the simple lifting of this flap had been felt instantly within the cranium, and exhibited itself by the strong adhesion between the dura and the bone. A severe contusion, therefore, it can easily be understood, even without fracture of the bone, might set up such inflammation as would ultimately lead to suppuration, to the formation of a cyst or a tumor, or to such organic changes as would be followed by epilepsy. Williams[65] has reported an unusual case in which a blow on the forehead produced an abscess which discharged through the nose.

Compression of the Brain.—In 1885, in a paper read before the American Surgical Association, Roberts insisted that the complexus of symptoms passing under the title of "compression of the brain" was due not so much to compression as to brain injury and inflammation. In cases of encephalic hæmorrhage, we certainly have an example of compression. Apart from this cause, and probably from tumor and from effusion, in both of which, however, inflammation has a large share, I certainly would agree with the position taken by him. A blow which is followed by symptoms of compression, when it is sufficiently serious to produce violence to the membranes, or laceration of the brain tissues, is, as a rule, one which has been followed by inflammation; and it is this inflammation with its exudation and swelling that causes the mischief. We are apt to think of increased intracranial pressure as a result to be looked for only from tumor, abscess, or effusion into the ventricles. But it is certainly reasonable to believe that mere inflammation of the cranial contents will be attended by swelling as in other tissues, and that thereby the intracranial pressure will be increased.

An experiment by Felizet is full of instruction. He filled a skull with melted paraffine, and after this had cooled, he let the skull fall from a moderate height to the floor. The calvaria was then removed. No fracture existed but the surface of the paraffine was flattened at the point corresponding to the blow. The skull had been momentarily depressed, and had returned again to its former shape by its elastic resiliency. Undoubtedly the same occurs in the brain, and no such momentary changes of form from violence, even though followed by its restoration to its original place, can have been produced without more or less laceration of the brain tissue. What is to be feared is that inflammation will take place, and that the products of inflammation will produce symptoms of pressure. Hence, in such cases I would trephine for the same reasons as are given under the last heading, if similar symptoms arise.

Scalp Wounds and Injuries of the Head.—In every case of scalp wound, the head should be shaved over a large area, and scrubbed with a nail brush and soap and water, followed by ether, and then with a sublimate solution It should, of course, by this process be thoroughly cleansed from all dirt and foreign substances, and if need be the edges of the wound should be trimmed in order to get entirely rid of the dust and dirt. The wound may now, and not until now, be examined by a probe and the finger, both of which must be entirely aseptic Should the injury be limited to the scalp and the periosteum, after providing for drainage by horse hair the wound should be closed and dressed antiseptically. But should the skull be fractured, it should be treated as described below. In wounds which produce a crushing or sloughing of the scalp, Dr. William Hunt has called my attention to the fact that the depressed scar resulting from loss of scalp tissue only, not seldom may be mistaken for an old depressed fracture of the skull—an error he has known to be made by more than one good surgeon.

Simple Fracture of the Skull without Depression.—This is often exceedingly difficult to diagnosticate. One of my patients, a bright, intelligent fellow, experimented on his own head the morning after a fall of nine feet, by tapping on his head on the injured side. He elicited a "cracked-pot" sound which did not exist on the uninjured side. It is possible that this may be hereafter of great value in diagnosticating simple fracture without depression. Whether this can only be heard by the patient, or whether it can be heard by the surgeon as well, with or without the aid of a stethoscope, I have as yet had no opportunity of determining; but it should be a matter of careful investigation, and be reported upon, with a view of utilizing it hereafter. If the fracture be simple and without depression, and without cerebral symptoms, it should be treated expectantly, but the moment that there are any symptoms of encephalitis the trephine should be used for the reasons previously stated. Two most instructive cases of such trephining are reported by Heusner.[66]

Simple Fracture with Depression.—In simple fracture with depression I should certainly advise immediate preventive trephining, even if there be no sign of encephalic mischief present, although I am quite aware that many conservative surgeons are opposed to such radical treatment. As already stated, the conversion of a simple fracture into a compound one is at present attended with no serious risk. It must be remembered that any violence, sufficient to break a bone and to depress it, will unquestionably have produced some laceration of the brain substance, and possibly of the dura. In addition to this, as the inner table is so much more easily fractured than the outer, it is always possible that a fragment may have been detached and driven into the brain. The immediate dangers arising from such a fragment of bone and laceration of the cerebral tissues and membranes are those of serious inflammation, and if the products of inflammation are confined within the skull, without possibility of escape by drainage, the danger is a serious one. Even should the patient recover, as is undoubtedly often the case, the numerous instances of epilepsy arising from irritation of a scar, from a cyst, or from secondary degeneration, are so great, and the danger of trephining so small, that but little choice would seem to exist.

The last four years have certainly remodelled our views as to intracranial surgery, and have shown that lesions of the brain should have the same opportunity for drainage and for the escape of wound products that the soft parts have. The harmlessness of trephining, with modern methods, is so marked that no patient should be allowed to take his chances in the hope that neither the immediate nor the remote consequences will follow. Trephining in this case, to be of use, must be done early. Nancrede[67] has insisted on the great advantages that accrue from early operation, and Bryant (*Lancet*, 1888) has re-enforced the same views. An investigation of most of the cases which have been operated on by Macewen and Horsley and others, will show clearly the mischief that arises from neglect.

Compound Fractures of the Skull.—The rule in such cases should be always to explore by a large incision in the scalp. Should there be no depression, no strong probability either of separation of the inner table or of serious laceration of the brain, or of hemorrhage, the wound should be most scrupulously disinfected, and, after careful antiseptic dressing, the expectant plan should be pursued. Should the fracture be a mere linear fissure, after careful disinfection, if the fissure be at all impregnated with hair, dirt, etc., the soiled edges should be carefully chiselled away so as to make sure that we have cleansed them of all infective material; for it is in the probable infection more than in the mere fissured fracture (apart from the violence of the accident) that the danger of complication resides lies. In doing this only the outer table need be cut away. An antiseptic dressing should be then applied.

But if depression exists and there are symptoms which lead us to believe that serious injury to the brain, or fracture of the inner table, or hemorrhage exists, preventive trephining should be done at once. It goes without saying that a large area of the scalp should be shaved and most rigidly disinfected in all these cases.

Mr. Mayo Robson[33] has reported an excellent illustration of the value of comparatively early trephining in such cases. A man received a blow on the left side of the head directly over the arm centre, the scalp showing a small lacerated wound. The right arm was paralyzed, which a surgeon who first saw him attributed only to bruising. Later rhythmic epileptiform spasms began in this limb, followed by facial paresis, oedema of the left optic disk, and exaggerated reflexes on the right side. Exploration showed a depressed fracture, and trephining saved his life. The twitchings disappeared in six days after the operation. Even had he recovered without operation he would probably have suffered from a Jacksonian epilepsy.

The very first case in Horsley's table, again, is a most instructive one as to the value even of late operation. In this he removed a scar in the brain (the result of an old depressed compound comminuted fracture, with loss of brain tissue) which caused two thousand eight hundred and seventy fits in the first thirteen days of his stay in the hospital! The operation was followed by improvement in his mental condition (though not of his paralysis), and no fits had occurred fourteen months after the operation.

In a case of extensive compound fracture of the occiput, so early as 1810, Hutchison[34] boldly anticipated modern surgery with the happiest results. The patient had fallen thirty feet and fractured the occiput, into the foramen magnum, as proved at the operation. He was trephined at once and, to the embarrassment of the surgeon, the dura bulged beyond the outer surface of the bone, and by its elasticity showed that there was an extravasation of blood beneath it. The next day this was incised, the blood evacuated, and, after a tedious illness from a suppuration that would now happily be conspicuous by its absence, the patient recovered.

In *punctured wounds of the brain*, which are of course always compound fractures of the most dangerous character, the rule should be *absolute* to trephine at once, whether there be brain symptoms or not. The almost certain danger of severe inflammation, and the need both for immediate provision for drainage and for antiseptic cleansing of the wound, render immediate trephining imperative, just as incision, cleansing, and drainage of a similar wound in the soft tissues is the rule. No better illustration could be given than a case reported by Bull[35] in which a man was struck on the left temple with a penknife. The wound was not considered serious enough to warrant his admission to the hospital where he first applied. Ten days later aphasia, word-blindness, and word-deafness set in, without paralysis. Five days later he was trephined. The knife-blade had penetrated the dura and wounded the brain. A clot was removed and drainage provided for. The next day his aphasia recurred, but disappeared after the blocked drainage-tube was made pervious and further clots removed. An excellent recovery followed.

Wagner[36] states that in eighty-one cases of complicated vault fractures of the skull *freshly* treated as above advocated, the death-rate was only 1.23 per cent.; whereas in twenty such, treated secondarily, the mortality was 60 per cent. No better commentary could be made.

GUNSHOT WOUNDS.—Recent experience in cerebral surgery will undoubtedly, in the near future, entirely revolutionize the treatment of gunshot wounds of the brain. The application of antiseptic methods to the treatment of brain injuries, the consequent boldness with which we can operate on the brain and its membranes, the introduction of the gravity probe and the making of counter-openings by the trephine, both to search for the bullet and for drainage, are the chief points in which recent practice differs from the old.

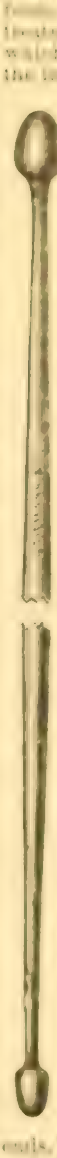

FIG. 4875.—Fluhrer's Aluminium Probe. [illegible]

The cardinal principles to be applied to gunshot wounds may be stated as follows: First, the scalp should be shaven over a large area around the wound or wounds, or, better still, over the whole head.

Next, the entire wound should be disinfected, from the wound of entrance all the way to the wound of exit, or to the site of the ball, if the missile has not escaped.

Thirdly, If hemorrhage has taken place, either the wound of entrance or the wound of exit, or both, should be freely enlarged by the bone-forceps or by the trephine, and the vessels secured by catgut ligatures, or, in rare cases, be controlled by pressure or by haemostatic forceps.

Fourthly, The bullet or other missile should, if possible, be removed, if need be, by a second trephine opening.

Fifthly, Absolute free drainage should be secured, again, if need be, by a counter-trephine opening, even if the drainage-tube should have to traverse the entire brain.

Sixthly, Antiseptic dressings should be applied, and the subsequent treatment of the case be conducted on general principles.

The admirable cases of Fenger and Lee,[37] Fluhrer,[38] Nancrede,[39] Bryant,[40] and others have proved conclusively the truth of the above maxims, and the next war will tell as different a story in cases of penetrating wounds of the head as it will in penetrating wounds of the abdomen.

Of the above points several have already been considered. The *removal of the ball* has always been one of the chief difficulties in cases of gunshot wounds. Fluhrer, in the brilliant article alluded to, has shown, however, a new method which is of the greatest importance. The wound having been suitably disinfected, together with, of course, the hands of the operator and the instruments, etc., the head of the patient is so placed that the probable direction of the ball will be vertical. The gravity probe of Fluhrer, made of aluminium, with large rounded ends, is now introduced by its larger end. This probe is so light that it will not force its large end into the brain substance and so produce a false passage, but by its own weight will follow the track of the ball, if this be vertical. If the ball be within easy reach it may be extracted by the ordinary methods; if, however, as shown by the probe, it has penetrated so far as to be more accessible from the opposite side of the skull, unless important centres lie in the way a counter-opening should be made on the opposite side of the skull at the point at which the probe would emerge if pushed through. The proper point for the counter-opening can be best located by the point of intersection of the lines determined in various planes by the method described by Bryant.[40] Figs. 4876 and 4877 show the method plainly. Before the probe has been

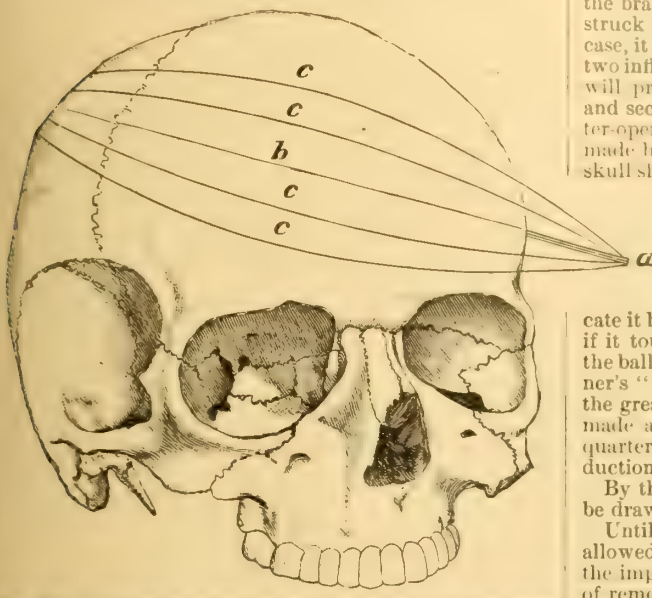

FIG. 4876.—*a*, The extra-cerebral portion of the probe ; *b*, the line taken by the probe through the brain ; *c*, *c*, *c*, *c*, lines placed in the direction of the probe with the aid of a string.

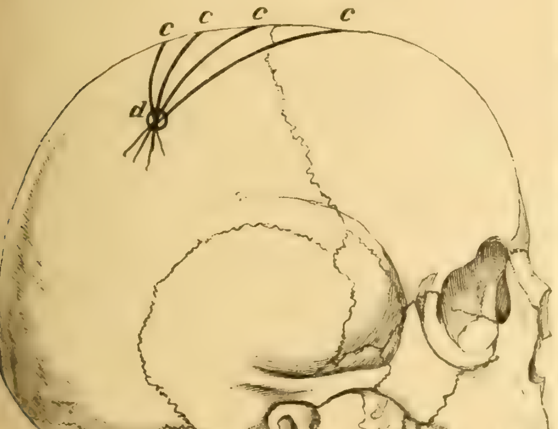

FIG. 4877.—*c*, *c*, *c*, *c*, Lines converging on the opposite side of the head ; *d*, point at which to trephine.

introduced in the search for the ball its length should be measured. If, then, it impinges against the ball, by measuring the protruding part of the probe the difference in the two measurements will give the depth at which the ball lies. Pushing the probe through to the counter-opening, and again measuring the part protruding from the original opening, we ascertain the depth at which the ball lies from the counter-opening. The probe is now to be carried entirely through the counter-opening and two strands of antiseptic silk are attached to its extremity, and on withdrawal of the probe the strands of silk will lie in the track of the wound. To one of these is now attached a No. 9 (French) gum catheter, which should be new and carefully disinfected, especially in its interior, and within it should be a disinfected straight stylet in order to give it rigidity. The stylet being ensheathed by the catheter will not mislead by its metallic sound or feel in the search for the metal ball. A pair of forceps is now tethered to the catheter by a loop of silk round one of its arms, and the ball is searched for at its known depth, above, then below, then to the right, and lastly, to the left of the catheter-guide. Between searching in any one direction and the following one the forceps should be entirely withdrawn and reintroduced so as not to swing around the catheter and thereby, perhaps, injure the brain substance unnecessarily. In case the ball has struck the opposite side of the cranium, as in Fluhrer's case, it will have rebounded in the direction determined by two influences : first, the natural angle of reflection, which will probably be about equal to the angle of incidence ; and secondly, the influence exerted by gravity. A counter-opening having been made, the wound in the meninges made by the ball in impinging on the opposite wall of the skull should be sought for, and from this, as a new point of departure, a new search may be made in the same manner as above with the gravity probe. Two other instruments may be used, also, in determining the site of the ball. They are the very ingenious invention of Dr. Girdner.[76] The "telephonic probe" if it touch the ball, will indicate it by a grating sound, a sound which is not produced if it touch any other than a metallic substance. Should the ball be but a short distance below the surface, Dr. Girdner's "induction balance" will indicate its position with the greatest accuracy, and the counter-opening should be made at the nearest point to the missile. Two and a quarter inches is the maximum depth at which the induction balance will locate it.

By the second strand of silk a drainage-tube may now be drawn entirely through the wound.

Until recently missiles that lodged in the brain were allowed to remain there unless easily accessible, under the impression that meddling with the brain with a view of removing anything that may have lodged there was entirely unwarrantable. This we now know is an error. The missile should in all cases be removed if accessible. Dr. Wharton[77] has presented the analyses of 316 cases in which foreign bodies were lodged in the brain. As a result of this investigation in 106 cases in which removal was effected, 34 (32 per cent.) died. Of the much larger number, 210, in which the missile was not removed, 122 (58.1 per cent.) died, and of those who lived 10 died from the ultimate effects of the ball, and many of the others suffered from epilepsy and physical and mental deterioration.

Arnold, at the request of Bryant (*loc. cit.*), investigated very carefully 140 cases and found that of the 85 cases in which the missiles escaped primarily, or were removed, 38 (44.7 per cent.) died. Of the 55 in which the missile was not removed, 32 (58.2 per cent.) died, giving nearly the same result as Wharton's tables.

If the bullet has not escaped, and cannot be found or removed directly, or by a counter-opening, the wound should be carefully disinfected and thorough drainage should be secured by a rubber tube carried to the entire depth of the wound. If, however, a second opening has been made, the drainage-tube should be carried entirely through the track of the wound.

Drainage should be kept free and thorough, and antisepsis secured by a gentle syringing with some suitable antiseptic solution, but it should be done with care and with a weak solution.

FRACTURE OF THE BASE OF THE SKULL.—Besides the ordinary dangers from fracture of the vault of the skull, we have at the base another danger of great importance, that does not at first glance seem to be present, viz., probable and insidious communication with the external air, and, as a result of it, septic infection that is apt to be overlooked. This communication with the outer air may take place either through the ear, the nose, or the roof of the orbit.

Fracture of the occipital bone, involving the base of the skull, should be dealt with, of course, as in the case of fracture of the vault.

Heretofore fracture of the base has been excessively fatal, and it is a remarkable fact in cerebral surgery that Wagner, in the lecture already referred to (p. 89), states that in twenty three cases of fracture of the base that survived the first forty-eight hours (that is to say, those which did not die from the severe primary violence) every one of them recovered.*

If the communication with the air be through the ear, as shown by escape of the cerebro-spinal fluid, the first thing to do is most carefully to disinfect the ear, after having removed all of the wax, hair, etc., within it. This disinfection should extend to all the hollows in the external ear and the surrounding scalp, which last should be shaved. The ear should next be filled with boric acid, and the ear and scalp should then be covered with sublimate gauze. I have no confidence in iodoform, but [illegible] vastly superior.†

Should the fracture of the base involve the roof of the orbit and not communicate with the external air, of course it should be treated as a simple fracture without operative measures, unless the subsequent history should demand it. But should such a fracture be caused by an umbrella-tip, a splinter of wood, a pair of scissors, or other such penetrating body, then the eyebrow should be shaved off, and the whole region about it be carefully disinfected (special precautions being taken to keep the solution from injuring the eye, as, for example, by closing the lids with rubber plaster). After disinfection by bichloride solution (1 to 1,000) a solution of boric acid (1 to 100) or hydronaphthol (1 to 500) should be used. An incision should then be made in the line of the eyebrow, in order to hide the subsequent scar, the lid drawn down, the track of the wound carefully disinfected, and a considerable opening made in the roof of the orbit by a gouge or chisel, rather than by a trephine. If the brain itself has been injured, the dura should be opened, and the track of the wound again disinfected. Thorough free drainage should be provided for, and the wound treated as usual.

Should the fracture involve the nose, the same principle would apply, viz., thorough disinfection and free drainage. Trephining here should be through the track of the exterior wound, if it involve the base of the nose or lower forehead. If the penetrating body has passed through one nostril, of course the nostril should be first washed clean and then disinfected with boric acid or hydronaphthol, and, after trephining, the same acid should be thoroughly instilled into the nostril, both from below and by way of the trephine opening. The trephining would probably be done best just above the root of the nose, and would, unfortunately, involve the frontal sinus, which should always be avoided if possible. But the great danger from want of drainage must overcome every objection of a minor character. The frontal sinus, as well as the wound, should be disinfected, therefore, with great care, and the same drainage and dressing be applied as heretofore recommended. In order to prevent the passage of infective air through the nose, both from without and from the lungs, it would be well, perhaps, to plug up both anterior nares with a moderate tampon of soft sublimate gauze for the first three days at least. A tampon in the anterior nares would nearly prevent any current of air through the nose, even from behind. In children it is to be remembered that the frontal sinus is very small and ill developed.

INTRACRANIAL HÆMORRHAGE, ESPECIALLY FROM THE MIDDLE MENINGEAL ARTERY.—Three papers recently published have practically settled the question of the treatment of hæmorrhage from the middle meningeal (Wiesmann in the *Deutsche Zeitschr. f. Chir.*, Bd. 21 and 22, 1885; Jacobson in "Guy's Hospital Reports," 1886, vol. xliii.; and Krönlein in the first journal, Bd. 23, Hft. 3 and 4, 1886).

The violence that may rupture the middle meningeal is but slight in some cases, so slight, indeed, as even to leave no mark. A fracture may exist, but it may be so small as not to be recognizable by the touch, and barely by sight. In a number of cases there will be no fracture whatever. Stokes [illegible] reports a case which is a model of diagnosis and treatment, in which, after only a bruise, trephining evacuated a clot one and one-half inch thick, followed by immediate relief to the paralysis, and speedy recovery. Jacobson (loc. cit.) reports four cases out of seventy, of such hæmorrhage, in which no fracture existed. In some, of course, the fracture will be both visible and palpable, not only over the vault but also at the base of the skull. Either the trunk or the branches may be ruptured. Of the seventy cases tabulated by Jacobson, in two certainly, and in four others probably, the trunk was injured; but the divisions beyond the trunk are the site of the lesion more commonly than the main trunk itself.

The adhesions of the dura to the skull, it should be remembered, while in general very strong, are very slight in the area of the middle meningeal, as pointed out by Tillaux, and so favor hæmorrhage.

The symptoms of the greatest value are: First, An interval of consciousness between the accident and the appearance of serious symptoms. This interval of consciousness is of the greatest importance, and probably is worth all of the other symptoms put together. It is due to the fact that it takes a certain amount of time for sufficient blood to escape to produce unconsciousness from pressure. It was present in two-thirds of Jacobson's cases. If the main trunk be injured, or one of its larger branches, and the blood poured out rapidly, this interval will be very brief, and coma and death will quickly supervene. But not uncommonly it will be some hours long, or occasionally even days. But even if brief, its possible existence should always be inquired into, and if present the other signs of intracranial hæmorrhage should be looked for with care. Secondly, Hemiplegia on the side opposite to the hæmorrhage. This may be progressive, the hemiplegia extending from one portion of the body to another, as the extending clot presses upon one cortical centre after another; as, for example, if the clot be effused over the face centre, the face muscles will be paralyzed first, and as the blood clot extends upward over the arm centre, paralysis of the arm will follow. Such extension is extremely significant. The paralysis, however, may exist on the same side as the injury, if the artery has been ruptured on the side opposite to the injury, as has not infrequently happened. Clark [illegible] in just such a case trephined on the same side as the injury and the paralysis, and lost his patient, who had a clot in the side opposite to that of the injury. Sometimes, though rarely, both arteries may be ruptured, as in the remarkable cases of Hill (Cases 18 and 19, Jacobson's paper). If there be no paralysis, the dilated and immobile pupil on the side of the clot may assist the diagnosis. Thirdly, The pulse becomes frequent. Fourthly, The respiration becomes slow and stertorous. Fifthly, If the clot extends toward the base, the pupil on the side of the clot will be dilated and immobile; and if the clot be on the left side, aphasia also will take place. Sixthly, The temperature will probably rise; it may be quite suddenly, and up to 101°, 102°, or even 104° F., especially on the side opposite to that of the clot, according to Hersey.

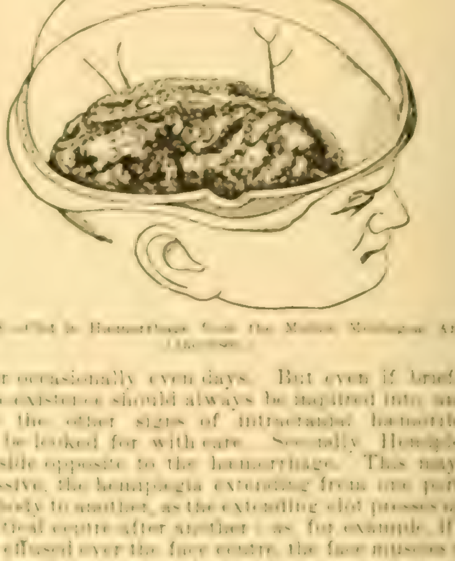

FIG. 1575.—Clot in Hæmorrhage from the Middle Meningeal Artery. (Jacobson.)

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* It is interesting, however, as the most [illegible] of [illegible], to [illegible] the [illegible] of all these cases [illegible] the [illegible].

† [illegible] the experiments of [illegible], Medical News, December [illegible], 1888, and [illegible] in the journal of [illegible] for March, 1889.

The importance of operative treatment is best shown by Wiesmann. Of 147 cases treated expectantly, 131 died (89.1 per cent.); of 110 cases treated actively, only 36 died (32.7 per cent.)! Besides this, in the majority of these cases ending fatally after operation, the *extravasation was not reached, and the clot therefore was not removed.* When, therefore, any of the above symptoms are present in a case showing a reasonable ground for believing that the middle meningeal, or its branches, have been ruptured, even though some doubt exist, the skull should be trephined.

As to which side of the skull should be operated upon, we should be guided by the localizing symptoms rather than by the site of the injury. Krönlein, in the last three years, has trephined four cases of rupture of the middle meningeal, and in two of them removed the clot, and the patients recovered. In the other two he failed to find it, and both patients died. He states that in by far the greatest number of cases the clot will be best reached by trephining at a point one inch behind the external angular process of the frontal bone, at the level of the upper border of the orbit. Should this not reach the clot, he strongly urges that another trephine opening be made just below the parietal boss on the same level as the former. By not making this last opening he lost the two patients alluded to. By the anterior opening access is had to the main trunk and the anterior branch of the middle meningeal, and by the posterior to its posterior branch. As in not a few cases there will be doubt as to whether the rupture is in the anterior branch or trunk, or, on the other hand, in the posterior branch, the need for the second opening, in case the first does not disclose the clot, is apparent. Having made one or both of these openings, the clot should be removed, and either opening, if necessary, enlarged by the rongeur forceps in order to obtain access to it. If the pupil be widely dilated, showing that the clot has extended downward toward the base, the trephine should be applied about half an inch below the level of the upper border of the orbit, rather than at its level.

Should the middle cerebral artery be wounded, it must be secured by ligature. No diagnosis can be made at present between hæmorrhage from the middle meningeal and the middle cerebral; hence the discovery that the middle cerebral is wounded would follow a trephining at the point already indicated for the meningeal, viz.: an inch behind the external angular process. If the bleeding-point on the middle cerebral be not accessible here, as the artery lies in the fissure of Sylvius, the trephine opening should be enlarged by the rongeur forceps, upward and backward, in the line of the fissure, *i.e.*, in the direction of the parietal eminence. The case reported just below is an excellent instance of ligature of one of its branches.

The clot-cavity should be washed out, after the hæmorrhage has been controlled, by a weak antiseptic solution or cooled boiled water. Drainage should be carefully provided for, and the wound dressed in the usual way. Weir, in May, 1885, was the first, I believe, to propose that in case the first trephine opening would not answer well for drainage, a second one should immediately be made. In doing so, not only must the position of the clot be remembered, but the second trephine opening should be made also in such a position as to favor drainage in the recumbent posture. As a secondary measure, it was done by Noyes as early as 1882, and later by many others.

The following case, furnished me by Dr. Dench, by the kind permission of Dr. W. T. Bull, of New York, illustrates well several points above mentioned. A man, aged twenty-one, was brought into hospital in August, 1887. He had been shot at a distance of twenty feet, the ball entering at a point two and a half inches to the left of the middle line, just behind the biauricular line. When first seen his right arm was paralyzed, but shortly afterward when admitted to the hospital, this paralysis had extended to the leg, with ptosis and left external strabismus. The pupils were equal and dilated. The pulse was slow and the patient unconscious. A probe was passed directly into the cranial cavity, but the ball could not be found. Intracranial hæmorrhage was diagnosticated from the progressive paralysis. The wound, therefore, was exposed by a crucial incision, several fragments of bone were removed, and considerable arterial blood gushed from within the skull. Motion immediately returned in the right leg. The patient was then trephined a quarter of an inch below, and in front of the wound, and the dura, which bulged into the wound, was incised. The original wound and the trephine opening were then made into one by forceps, and the bleeding meningeal artery was exposed and tied with catgut. A large branch of the middle cerebral, which had been severed, was likewise tied. There was no evidence whatever as to the location of the ball. The wound was disinfected, and drainage and antiseptic dressing were applied. A hernia cerebri followed. The wound healed in a little over two months, no rise in temperature having taken place and no pus having appeared. He could speak perfectly well and could use his arm, but not his hand. He was, however, subject to ungovernable attacks of temper.

Another admirably managed case is reported by Owen.[60] Under the head of hæmorrhage should be mentioned, also, a remarkable and instructive case, reported by Dr. T. Grainger Stewart and Mr. Annandale,[61] of traumatic pachymeningitis interna, accompanied by hæmorrhage. In consequence of a fall on the occiput, without visible lesion of the skull or scalp, in two months there was gradually developing vertigo and frontal pain, increasing optic neuritis, gradually developing stupor, right hemiplegia and aphasia, with subsequent normal temperature. Annandale trephined over Broca's convolution, and found under the dura a space extending three inches behind and two inches in front of the trephine opening, which was filled with brownish-red fluid. Temporary improvement occurred, but he died five days later. The post-mortem showed inflammation of the cerebellum, diffused lepto- and pachymeningitis, with hæmorrhage of the cerebrum on both sides, with red softening on the left side. This was evidently of inflammatory origin, and it is not improbable that in such a case as this, and in those of serous apoplexy, very early trephining might result very differently.

Ceci (quoted by v. Bergmann, *loc. cit.*, p. 112) also has reported a case of chronic hæmorrhagic pachymeningitis, the result of a blow, in which palsy, incontinence, and coma were present. He trephined over two months after the accident, evacuated the blood, and his patient recovered and regained all the motor functions except those of the left hand (slight paresis).

In the *British Medical Journal*, March 2, 1889, Spencer and Horsley report some remarkable experiments on the possibility of controlling hæmorrhage from the middle cerebral artery and its branches by pressure on the carotid. The ingravescent form of apoplexy from such a rupture, impending apoplexy from intense cerebral congestion, and some of the severer congestive headaches may possibly prove capable of relief by this means. The reader must consult the original paper for the grounds upon which their conclusions are based.

INVETERATE HEADACHE.—Horsley (Case 7 of his table) and von Bergman (*loc. cit.*, p. 113) have published two cases of relief of fixed and excessively severe localized headache by operative interference. In Horsley's case he trephined at the seat of pain and removed a piece of the parietal bone, the inner table of which had been perforated and was being eroded by a Pacchionian body. Relief from pain had continued for five months after the operation.

In von Bergman's case, after all ordinary means had been exhausted, the bone was exposed. Its color was dark and purplish, as if extravasated blood were seen through it. It was greatly thinned, so that he was able to cut it with his scalpel. A quantity of tea-like dark blood escaped, and the pulsating dura was seen beneath. Six months before the operation a stone had struck him on the head, without, however, wounding the skin. This had been followed by considerable localized swelling, and the headaches began some weeks after the injury. As soon as he recovered from the effects of the anæsthetic his headache was gone, and the relief had continued for certainly three years.

A somewhat similar case presented itself to me a few months ago. A man had fallen on his occiput and had suffered from such severe headaches as to be entirely incapacitated for business. In addition to the headaches there had been repeated paralysis of the face and extremities. These, however, were of a temporary character. Furthermore, the patient gave a very probable history of syphilis. These considerations, coupled with the fact that the site of the cerebral lesion seemed to be so doubtful, led me, after consultation with Drs. Mills and Osler, to advise against an operation. The patient afterward consulted Dr. Weir, of New York, who, disregarding the medical aspect of the case, trephined with a view of relieving the headaches. Whether from altered intracranial pressure or from other reasons I do not know, but certain it is that for three months after the operation, when last heard from, the patient was entirely cured of his headaches. I should add that vigorous anti-syphilitic treatment had been without effect. As Dr. Weir informs me, the dura was not opened, nor was the button of bone replaced.

Such operations seem, therefore, to be entirely justifiable in view of the very small risk to life from trephining; provided, of course, that the headache be really so constant and severe as to justify a reasonable risk, and that all suitable medical means have been faithfully and ineffectually tried. Very probably, as in the first and last cases, simple trephining without opening the dura may be all that is necessary to effect the cure. In cases of suspected syphilis the iodides should be pushed, on the American plan, if necessary, up to half an ounce a day before a decision in favor of operation can properly be made. Just such a persistent, severe headache (of syphilitic origin) has recently been under my care, and has in this way been cured, and an operation avoided; less than three drachms a day, it was found, did absolutely no good.

Cole reports an obscure case of such pain existing for a year and so severe that the patient tore all the hair off the right side of his face. He had paralysis and atrophy of the muscles of mastication, with loss of taste and unilateral deafness. The teeth of the same side all dropped out, and the cornea sloughed. The diagnosis was a syphilitic neoplasm between the pons and medulla, and the basilar process. Though this diagnosis seems to have been a very questionable one, yet his treatment, after all anti-syphilitic remedies had failed, was most successful. He trephined behind the base of the mastoid and punctured with a fine trocar, but only evacuated some cerebro-spinal fluid. The patient rapidly recovered from the operation, lost his pain after two days, and was recovering power in the muscles of mastication.

MENTAL DISTURBANCES.—So far as I know there has been only one case, and that a notable one, in which a psychical disturbance has suggested the true diagnosis, which in turn was followed by a successful operation. This was reported by Macewen. The man had received an injury a year previously, and was suffering from melancholia, with homicidal tendencies. These were relieved by paroxysms of pain, which were not well located. There were no motor phenomena, but it was discovered that immediately after the accident, for two weeks, he had suffered from psychical blindness. He could see, but what he saw conveyed no impression to him. He recognized his New Testament by touching its smooth leather cover with the deep indented letters on the back, but on opening it the printed words were unknown symbols to him. At the operation the angular gyrus was exposed, and it was found that a portion of the inner table had been detached and had exercised pressure on the posterior portion of the supra-marginal convolution, while a corner of it lay imbedded in the anterior portion of the angular gyrus. The bone was removed from the brain and replaced in its proper position. He was greatly relieved from his mental state, though still excitable. He was at work when the case was reported, and had made no further attempts to his homicidal tendencies. This localization of a single mental process is of great importance, and leads us to hope that before long, by a more accurate observation of the mental processes in cases of injury, of disease, and of the lesions found at operation or at the post-mortem, we may be able to locate other mental processes in different parts of the brain. The fact that Macewen was able, by a careful and shrewd examination, to elicit so important a localizing symptom from a case which was obscure both in its history and in its visible lesion, is a matter of great encouragement. It is not perhaps too much to hope (as Ferrier and Horsley have also indicated) that hereafter we may be able to locate and deal surgically with lesions of mentality, as we do with those of the motor area.

Besides the case just alluded to, in which psychical symptoms led to the localization of the lesion, there are a number of cases on record in which insanity has followed injury and has been cured by operation involving the brain. One is reported by Hoffman. A man fifty years of age was made unconscious by a blow on the head which, however, produced neither fracture, convulsion, nor paralysis, but was followed by pain in the head and aphasia, and a tender spot above and in front of the right ear. Insanity developed after healing. The cranium was opened by a chisel over the tender spot. The dura bulged but did not pulsate. An incision evacuated a half ounce of cerebro-spinal fluid. The brain tissue had been lacerated by the blow. He recovered both from the operation and from his mental alienation.

McDonald reports a case of insanity following a pistol wound. The wound was three-eighths of an inch to the right of the middle line, and at the junction of the anterior and middle thirds of the first frontal convolution. The skull was opened eighteen months after the injury. There was no bone, but only fibrous tissue, at the point of injury. At the fourth puncture by a hypodermic needle, two drachms of serum were removed. On recovery from the anæsthetic the patient had recovered his mental condition.

Bennett and Gould report a case of a man, who received a severe blow 2¼ inches behind the meatus and 2½ inches to the right of the middle line. Six weeks afterward epilepsy developed, followed by mania, so that he was placed in an asylum. Trephining was done and the brain explored, in three or four different directions, to the depth of one inch, but nothing was found. The patient recovered both from his epilepsy and from his insanity.

Rannie reports the case of a woman who had tertiary syphilis. For eighteen months she had suffered with frontal and parietal pain on the right side, with tenderness of the scalp and discharge from the right ear, all of an intermittent character. There was no evidence of disease of the middle ear. She also suffered from visual hallucinations and melancholia. Her disease finally culminated in epilepsy affecting chiefly the left side, including the face. The attacks were followed by marked paresis on the left side. She was trephined over the right pre-Rolandic convolution. The skull and the dura were thickened. On opening the dura a small quantity of purulent fluid ran out which was found to come from a small degenerating gumma in the dura. Very slight opacity of the membranes existed. Three weeks later she was walking without any limp, and the motor power of the left arm was steadily improving. The headache and tenderness of the scalp had disappeared, and her mental condition was very much improved.

On November 30, 1888, I myself trephined a boy of eighteen, who had a thickened frontal bone just at the border of the hairy scalp, just to the right of the middle line, with obliteration of the diploë and eburnation of the internal table, the result of a fall from a wagon at five years of age. No fracture existed. At thirteen he developed epilepsy, and four months before I operated very marked delusional insanity began. No gross lesion was found in the brain, which was punctured four times by a director to a depth of 2 and 2½ inches. He recovered in a few days, and excepting two momentary delusions, he has had no further mental trouble, and only three fits in the next four weeks. The case will be fully reported later.

Briggs, Byrd, Garmany, and not a few other surgeons, have reported cases of mere trephining for insanity, but I have only referred to cases in which there has been interference with the brain itself by puncture, incision, etc.

Trephining for Arrested Development.—A case reported by Dr. Felkin and Mr. Hare[88] raises a very novel question as to whether, in some cases of arrested development, especially if it be the result of trauma, surgery may not be able to do something toward effecting rerecovery. The patient was a girl, seventeen years of age, who, when ten months old, had sustained a fracture of the skull, and as a result of it, the right arm and leg were completely paralyzed and shortened, badly developed, and with loss of function. The temperature of this side was two degrees lower than that of the other, the reflexes were exaggerated, and the sense of located tactile sensation was absent. Mr. Hare operated by trephining at a slight depression over the left motor area. The operation revealed a cyst two inches in depth, and an internal osteophyte half an inch long. The dura was not opened. The fragments of bone were replaced and healing took place without any rise in temperature. When the case was reported, about a month after the operation, the patient could walk better and also move the arm to a considerable extent. The condition of the reflexes and the temperature were alike on both sides. The case has not yet been reported in full, but when it is, it will give most important indications as to what we might possibly do in future cases.

Tapping of the Lateral Ventricles as a Definite Surgical Procedure in Meningitis with Effusion, and especially in Tubercular Meningitis.—In a brief address at the Washington Congress of American Physicians and Surgeons, held in September, 1888, I used the following language: "We distinguish in the body three cavities, the cavity of the head, the cavity of the chest, and the cavity common to the abdomen and pelvis. In the chest, and in the abdomen and pelvis, we recognize a large number of distinct viscera with separate and distinct functions. We can investigate the diseases of each viscus and locate them according to the physical signs and the symptoms presented by the history of the case. Until very lately the head was regarded as a cavity containing but one viscus, acting in its entirety like the liver, spleen, or kidney. If it were affected, we were not able to distinguish one part from another. But in my opinion we ought to regard the brain cavity precisely as we regard the chest cavity or the abdominal, as a cavity containing a number of viscera, fused physically, but separate physiologically and pathologically." In a later paper,[89] read before the College of Physicians of Philadelphia, November 7, 1888, I said: "I would go further now, and draw a similar analogy between the serous membrane of the abdomen and that of the brain, and plead for a similar treatment for both in case of similar disease. Since we now open the belly and drain for tubercular peritonitis with such remarkable success, I would propose that we do precisely the same for the brain. That it may be done without serious injury to the cerebral tissue, the history of the case here related I think abundantly shows, and also that it is *more* urgent and necessary in the brain than in the belly or chest. In the belly and chest the walls are more or less yielding, and the viscera to a large extent spongy. They can bear a great deal of pressure with little damage to their integrity or to life itself, if the pressure be relieved within a reasonable time. Not so in the cranium. The walls are rigid and will undergo but little pressure (unless it is very gradual, as in chronic hydrocephalus) without producing death. The fatal issue is so uniform that any means which holds out a reasonable hope of relief, even if it involve great risk of life, should be tried. The proposal in the present paper seems to involve but moderate damage to life, and to offer possibly high hopes of success."

The proposition made in this paper was, that in the case of meningitis with effusion, and especially in tubercular meningitis (and the same would be true in the so-called serous apoplexy), trephining should be done and the lateral ventricle tapped as a definite surgical operation.

It may be objected that much draining of the cerebro-spinal fluid would be dangerous. I answer, firstly, we do not know until we try. Secondly, in my brain tumor case there was probably a very slight wall between the cavity occupied by the tumor and the lateral ventricle. This wall subsequently ruptured and gave exit to a quantity of cerebro-spinal fluid sufficient to wet an ample sublimate dressing continuously for three weeks. In Horsley's case of spinal tumor very abundant drainage continued for a long time. In the Comptes Rendus, 1888, cvi., 1693, Championnière reports a case in which no ill results followed such an abundant flow of the cerebro-spinal fluid as to wet the pillow, the dressings, and the bed. Such abundant and long continued drainage does not, therefore, seem to be dangerous. Thirdly, experience may show us that possibly, in the head as in the abdomen, simple evacuation of the fluid without its continuous drainage may not only be feasible, but best. Of course, for pus in the ventricles the drainage should be prolonged, if, indeed, so fatal a lesion allow of any treatment. Possibly even this may not be necessarily mortal, for Professor Joseph Pancoast[90] reported a case of abscess communicating with the lateral ventricle, in which death resulted on the sixteenth day, apparently from obstruction to the escape of the pus. See also the case referred to on p. 216.

I have not yet had an opportunity of performing the operation in any case, although in the case related in the paper referred to, my drainage-tube was within *a quarter of an inch* of the lateral ventricle; but I am so thoroughly convinced of the feasibility and the possibility of success that I offer it, at least, for the earnest consideration of the profession, in the hope that it may bear good fruit in the near future.

Baldwin[91] has recorded a remarkable case of brain injury opening the lateral ventricle. A hernia cerebri followed, and when this sunk in, the bottom of the cavity opened into the ventricle by a slit half an inch long and one-eighth of an inch wide. A fracture of the base as well as of the vault probably existed, yet the patient made a good recovery with hemianopsia. In the famous tamping-iron case the ventricles were also undoubtedly penetrated, yet the patient recovered. These cases, therefore, show that a wound involving the ventricles is not necessarily fatal. How much less, then, is an aseptic puncture likely to do serious injury!

In the *American Journal of the Medical Sciences* for January, 1850, Detmold has reported a case in which he opened the lateral ventricles and evacuated an abscess; but tapping the ventricles has never been proposed heretofore, I believe, as a definite and deliberate surgical procedure. The improvement in my case, from even the slight relief of intracranial pressure, leads me to believe that a more thorough relief from pressure might possibly result in cure. How incising and draining the peritoneal cavity in cases of tubercular peritonitis cures, I do not know, but certainly it is a fact, and why the same measures may not be followed by the same result in the serous membrane of the brain as in that of the abdomen, I do not see. Inasmuch as all cases of tubercular meningitis with effusion die, this uniform mortality seems to me to be the strongest possible argument for, at least, a trial of such an operation.

Operative Technique.—In doing the operation it is clear that we must avoid the motor zone, Broca's centre for speech, and any other well-defined centres for the special senses, and also the regions of the large blood-vessels of the brain, the middle meningeal, and the middle cerebral arteries. A number of experiments on the cadaver have led me to point out three practicable routes for the purpose. They are all, of course, only provisional, until experience shall show us a better one.

First, from a point from one-half to three-fourths of an inch on either side of the median line, and one-third of the distance from the glabella to the upper end of the Rolandic fissure. This is high enough to avoid the frontal sinuses, and is in advance of the motor area. A three-quarter-inch trephine opening having been made and the dura having been incised crucially, a grooved director should be thrust slowly into the brain tissue in the direction of the [illegible]. The director will traverse the first frontal convolution. At a depth of two to two and one-fourth inches the normal ventricle will be reached. Should it be distended, it would be reached at a less depth.

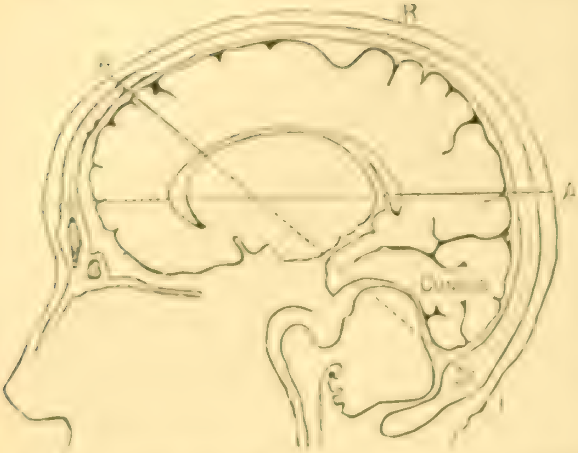

FIG. [illegible].—(Drawn by Dr. John M. Taylor.) Antero-posterior Section of the Head [illegible] R, Rolandic fissure. A and B [illegible] director [illegible] the dotted line showing [illegible] temporal convolution to the opposite [illegible] point.

Secondly. Trephine, etc., as before, midway between the inion and the upper end of the Rolandic fissure, one-half or three-fourths of an inch from the median line. This is high enough to avoid the cuneus, the wounding of which would produce hemianopsia. The director should now be slowly thrust into the brain toward the inner end of the supraorbital ridge on the same side. The director will traverse the precuneus, and the normal lateral ventricle will be reached at a depth of two and one-fourth to two and three-fourths inches from the scalp. A distended ventricle will, of course, be reached at a shorter distance.

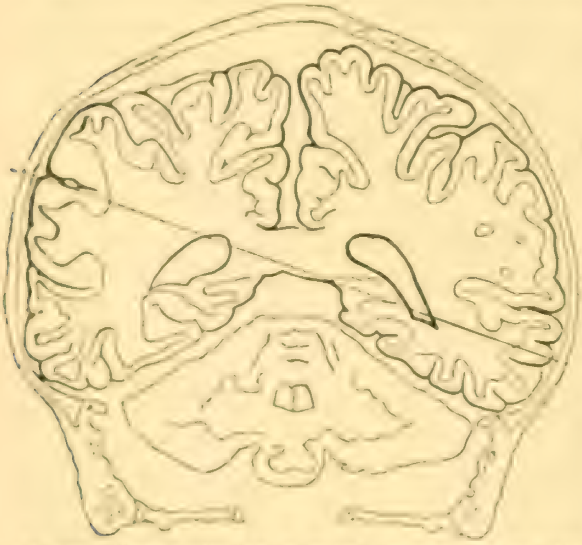

FIG. [illegible].—(Drawn by Dr. John M. Taylor.) Transverse Section of the Head [illegible] behind the meatus. The [illegible] line through the line of puncture; the dotted line [illegible] temporal convolution to the opposite side of the skull.

Thirdly. Trephine, etc., as before, one and one-fourth inch behind the external auditory meatus and one and one-fourth inch above "Reid's base line." This will expose the second temporal convolution. It is possible that this may be the site for hearing of the opposite ear, but it has been penetrated in a number of cases of abscess in the temporo-sphenoidal lobe without apparent injury to hearing. The director should be carefully thrust into the brain in the direction of a point vertically over the opposite meatus, and two and one-half or three inches above it. When at a depth of two to two and one-fourth inches the normal lateral ventricle would be reached, either at the beginning or in the course of the descending cornu. I have advised the use of the director rather than the hypodermic needle for the reasons already stated in the section on abscess of the brain. The fluid having been found, a bundle of horse hairs or a drainage-tube should be inserted for a suitable length of time. In order to prevent possible loss of the drainage-tube in the cranial cavity it may be passed through a button-hole opening in the flap and, if necessary, be secured to the flap by a stitch. To regulate the amount of drainage through the tube it may be closed by a disinfected wooden plug. In this a V-shaped slot may be cut, and the size of the slot will regulate the rapidity of the drainage. Whether the drainage shall be continued over twenty-four hours, a longer experience must decide.

Of the three proposed routes my preference would be for the present for the lateral opening. This route has a great advantage in that by it we can explore for abscess of the temporo-sphenoidal lobe, and also for effusion into the ventricles by the same trephine opening. The drainage could be either favored or hindered by the patient lying with the operated side down or up. Should prolonged drainage prove to be wisest, the posterior route might be the best one. The anterior route would hinder drainage, and as an additional disadvantage there would be a visible scar. As to a choice of which side to operate on, we should select the side of the diseased ear, if there be such disease, or if not, then that side which is tender either to pressure or percussion, or both.

Since the above was written my attention has been called to the fact that Wernicke[?] so long ago as 1881 proposed to tap the ventricles, and that Zenner[?] renewed the proposal. At the time of writing my paper I was wholly unaware of their propositions, and in referring to them I find that, while I must resign priority for the suggestion, I may claim that I have established exact rules for the operation and described its precise technique.

January 11, 1889, in my clinic at the Woman's Hospital, I first performed the operation. I found it easy and the rules I laid down proved to be correct. The patient was a fat and hearty boy, of four, suffering, it was thought probable, either from tumor or chronic meningitis with effusion, most likely a tumor of the cerebellum pressing on the straight sinus or the veins of Galen. There were no symptoms by which it could be more accurately located. His head had begun to enlarge about the early part of December, 1888, and measured 21¼ inches in circumference (exactly the measurement of my own head), with a biparietal diameter of 6¾ inches. At Christmas he became blind. For this he was brought to Professor George Strawbridge, to whose courtesy I owe the case. There was great choking of both disks and threatened blindness. The general health was good, and the temperature was normal. As the approaching blindness from the increased intracranial pressure was the immediate danger, I decided, with Dr. Strawbridge's assent, to tap the ventricles, and selected the lateral route. I removed a one-half inch button of bone, one and one-fourth inch behind the left meatus and one and one-fourth inch above Reid's base line. The dura pulsated and bulged. In the dura as in the skin, I made a small crucial incision. I then slowly introduced a hollow needle (of the size of No. 5 of the French catheter scale), into which I had already packed three doubled horse hairs nearly to the end. I introduced it toward a point two and one-half inches above the right meatus. At one and three-fourths inch from the dura suddenly I felt a marked diminution of the pressure and said to the class that I believed I had entered the ventricle, and in a moment the fluid began to escape. This fluid was found to contain sugar and albumen. It was slightly turbid, with small flakes in it.

The horse hairs were now pushed in as the tube was pulled out. About ℥ iij. of fluid escaped during the operation. An ample sublimate dressing was applied. During the first week from ℥ ij. to iv. escaped daily, and the choking of the disks diminished from 2.30 mm., to 1.09 mm., in each eye, the decrease being *measurable from day to day.* At the end of the first week I explored for a possible tumor by thrusting a probe in two directions into the left occipital lobe to the depth of three and a half inches. Finding no tumor I made a small opening, by a simple gouge, in the occipital bone, below and to the left of the inion. Through this I probed the left lobe of the cerebellum to a depth of two inches, and then obliquely across into the right lobe two and a half inches, but found no tumor. There was no reaction from these procedures, and the wound healed promptly. At the end of the second week the choking was reduced to 0.96 mm. As in spite of the drainage the swelling was subsiding very slowly, and Dr. Amy S. Barton, who kindly examined the eyes for me, reported that there was beginning atrophy of the nerves, I removed the horse hairs and introduced a small rubber tube into the ventricles. For a week this gave vent to from iv. to viij. ounces of fluid daily. Except a temporary rise of temperature, no reaction followed. At the end of four weeks, as the boy's general condition had deteriorated, especially when from choking of the tube the drainage was poor, I trephined another similar half-inch button at a corresponding point above and behind the right ear. I then explored the right occipital lobe as far as to the tentorium and falx, but found no tumor. I therefore tapped the ventricles from the right side by a drainage-tube. Following this, there was a brief but sharp rise of temperature to 104 F., which, however, quickly subsided. Four days later I washed out the ventricles from side to side by ℥ viij. of a warm boric acid solution (gr. iv. to ℥ j.), evidently to the boy's comfort, and with no results of a deleterious character. The boy died fifty-two days after the first operation. The post-mortem showed that at the site of the drainage-tubes, even after so long a time, there was not the slightest trace of inflammation either on the cortex or in the ventricular cavities, and the cerebro-spinal fluid evacuated at the autopsy was less turbid than that evacuated at the operation. There was not any perceptible trace of the various punctures. The cause of death was a tumor of the cerebellum. The probe had penetrated it, but as its density was about the same as that of the brain its presence could not be appreciated. Its nature has not yet been determined.

The case has shown clearly that the rules I formulated for the operation are exact; that the procedure is easy and safe; and that the ventricles may not only be drained, but even irrigated, without at least any deleterious results.

W. W. Keen.

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BRAIN, VESSELS OF THE. All the larger intracranial vessels and most of their easily visible branches lie in the enveloping membranes—dura, pia, and their processes. Over the convexity only minute branches enter or leave the brain proper. The largest arterial twigs directly entering the cerebrum are those of the (basal) pre- and post-perforated spaces. The largest venous rootlets directly from the organ are the corresponding perforants and some in the cœles. Hence the vessels of the meninges have to be included in any account of the encephalic circulation; and the vascular distribution—especially the arterial—can be best mapped out on the surface. From studies published within the last twenty years our knowledge of this subject has been greatly developed. Our aim is to reclassify and harmonize the often puzzling independent and rediscoveries.

Nomenclature.—In this article the simplified terms of Wilder (*v.* amended list in *New York Medical Journal*, November 25, 1885) will be employed. These are extended—with his approval—also to the veins, sinuses, and so-called meningeal vessels. As these last lie wholly in one of the membranes, the dura, the general term *meningeal* does not accurately define them; for this the unequivocal *dural* is substituted.

[illegible] Aspect of the Brain.

[illegible]

DURAL ARTERIES.

[illegible]

SINUSES.

[illegible]

DURAL VEINS.

[illegible]

Internal Veins of the Brain.

[illegible]

ARTERIES.—The encranial arteries present two distinct systems of vessels:

I. The dural, commonly called meningeal.

II. The cerebral, or those of the brain proper.

These latter do not anastomose with any other arteries. Rarely there are marked exceptions to this rule, and perhaps always slight anastomoses about the sella turcica.

Heubner (1874), from injections in adults, says: "The territories of the meningeal and of the cerebral arteries must be considered as absolutely independent of one another." Langer (1877), speaking of infantile and young subjects, states: *a*, that one or two dural branches of the pericephalic anastomose by the falx with terminal twigs of the dural artery; *b*, also that pia branches of the pericerebral may reach minute dural arteries accompanying the supercerebral veins as they spring over to the dura near the longitudinal sinus.

I. THE DURAL VESSELS ramify in the exterior of the dura. In a general way it is true that the pre-, meso- and post-dural arteries are branches respectively of the internal and external carotid and vertebral arteries. These various branches intercommunicate freely, so that dural infarction does not occur. They are distributed not simply to the dura, but also to the diploë cranial bones; small twigs may also pass to extracranial parts.

a. The branches from the External Carotid supply the middle belt, and, in fact, nearly the whole of the dura. They are:

1. The *mesodural*, the largest and most constant of all the dural arteries, arising from the internal maxillary and entering through the spinous foramen. Its branches pass up the divergent small meningeal (or arteries and accompanying veins) of the lateral cranial wall, connecting at the top with those from the opposite side. Of its two main divisions, the larger anterior is often for a short distance arched over in a canal.

Besides many minute branches to the sinus walls, outgoing nerves, and orbit (*e. lacrimal*), it may send to, or receive from, the deep temporal region minute rami perforating the interposed wall; in young subjects (Hyrtl) cerebral also branches may pass through the anterior fontanelle and the sagittal suture to the soft cranial coverings.

2. The *paradural*, an inconstant accessory meningeal, arising close to the latter, or even directly from it, and entering by the oval foramen. It goes to the Gasserian ganglion and adjacent dura.

3. The *mastoid* branch of the occipital (or external carotid 15 in 120 times, Wyeth, 1878), entering by the mastoid foramen, within which it always sends a branch to the diploë. It is small, variable, and destined for the wall of the lateral sinus and adjacent dura. Here again a reverse course has been observed, where the postauricular arose from a dural artery by emerging through a foramen in the mastoid (Bankart).

4. Separated branch of *ramus parietalis* also from the occipital, accompanying the emissary through the parietal foramen. It is usually insignificant, and often absent.

5. The *subdural* branches are very small and variable. They include twigs from the ascending pharyngeal, occipital, and stylomastoid arteries, enter by the pre- and post-lacerated, precondyloid and stylomastoid foramina, and partly supply the dura of the posterior fossa and basilar sinuses.

b. Branches from the Internal Carotid.—1. The cavernous carotid yields several small rami to the sinus wall, the pituitary body, Gasserian ganglion, and dura about the sella turcica. These are variously styled receptacular and [illegible] arteries, even precentral in case of any prominent single branch. Their field of distribution and that of the paradural are obviously complementary.

2. The *predural* usually refers to the one or more slight branches of the ethmoidal arteries supplying the adjacent dura of the precranial fossa.

c. Branch from the Vertebral.—The postdural artery arises opposite or just below the occipital foramen, passes with the vertebral into the cranial cavity, and supplies the dura of the postcranial fossa, especially the posterior portions, as the cerebellar falx, etc.

[illegible]

The only anastomoses of special interest, between dural and extradural arteries, are with those of the orbit. Such connections always exist. Often a medidural branch enters, through either the sphenoidal foramen or some special opening, and supplies the external wall, even substituting partly or wholly the lachrymal artery. Or a branch of the lachrymal may take the reverse course. Very rarely the medidural arises directly from the ophthalmic (Zuckerkandl, 4 cases, Hulston, 1), and then passes by the sphenoidal fissure to its usual distribution. This possible origin should be borne in mind in the rare operation of tying the medidural at the base of the skull.

II. INTRINSIC ARTERIES, or those of the Pia and Brain-substance.—In removing the brain from the skull we sever at its base the four arteries which suffice for its entire blood-supply. These are, anteriorly the two carotids entering through the carotid foramen and canal, posteriorly the two vertebrals entering beside the foramen magnum. By means of communicating branches at the base of the brain—the vertebrals having first united, and their common basilar trunk having divided into the two postcerebrals—the primary vessels combine to form the circle of Willis. From this practically all and only the *cerebral* arteries emanate. Previously, however, several branches are given off by the vertebrals and basilar; while the carotid yields only the ophthalmic. The latter is said always to originate before any of the cerebral branches, and some millimetres before the bifurcation of the carotid.

The vertebrals and basilar supply in their course the organs of the posterior fossa, viz., cerebellum, pons, oblongata, and their adnexa. In approaching the distal border of the pons the vertebrals unite to form the mesal basilar. This is occasionally divided within by a septum, or separates into two vessels which soon reunite. The basilar lies in the median sulcus of the pons, directly on the basilar process of the occipital bone; opposite the central border of the pons it ends in the two postcerebrals.

The lateral branches are:

1. *Postcerebellar*, the largest offshoot of the vertebral. It passes around the oblongata, beside the pneumogastric nerve, to supply the extremity of the cerebellar lobe as far as the median line, the subvermis and adjacent surface, and the plexus of the metepicœle.

2. *Recurrent spinal twigs*, also from the vertebral.

3. *Medicerebellar*, usually from the basilar trunk. This passes along the middle cerebellar crus to the preventrad surface of the respective cerebellar hemisphere, including the flocculus.

4. *Transverse* branches, three or four in number. These are parallel and accessory to the preceding.

5. *Auditiva interna.*—Starts like the last, but passes to the internal auditory meatus and structures of the inner ear.

6. *Ponticular* branches.—These immediately enter the pons perpendicularly, and supply its substance. They represent true terminal arteries (Heubner), quite comparable to the perforants of the cerebrum. From the importance of the tracts supplied they have likewise great interest to the pathologist.

7. *Supercerebellar.*—This starts near the end of the basilar, passes outward along the front border of the pons, winds around the crus cerebri near the optic lobes, and is distributed to the supervermis and general dorsal surface of the cerebellum. It also supplies the postoptic arteries.

The basilar branches all emanate at practically a right angle to the mother trunk. Those going to the surface anastomose much more freely than do the cerebral arteries. Accordingly Heubner found the pia-districts of single arteries much less definite over the cerebellum than over the cerebrum. Moreover, the branches of the two sides communicate dorsad across the median line; this is explained by the development of the cerebellum from a single median vesicle. The only communication between this system of vessels and the cerebral—except through the basilar trunk—is by small branches of the precerebellars and postcerebrals across the crura cerebri.

CIRCLE OF WILLIS.—The carotid ends at the outer angle of the chiasma in two main branches, the pre- and medicerebral arteries. At about 1 ctm. in front of the chiasma the two precerebrals are connected by the precommunicant. From either the medicerebral or the carotid passes the postcommunicant to the corresponding postcerebral. Hence the circle (or polygon) of Willis is made up by 1 precommunicant, 2 precerebrals, 2 medicerebrals (or 2 carotids), 2 postcommunicants, and 2 postcerebrals. This is the classical arrangement; from it, however, there are frequent and important deviations. Professor Windle found that it held in only 76, or, overlooking any disproportion in the postcommunicants, in 119 out of 200 cases. Only in the apes do the vertebrals nearly equal the carotids. In man, Ehrmann, from 157 measurements, found that very constantly the basilar trunk was equal to one carotid (*i.e.*, furnished one-third of the brain-supply). The communicants are not simply to re-establish a circulation in case of obliteration, but they normally act to equalize pressure in the local vessels. When this circle is complete and of normal structure, an adequate collateral circulation is established after occlusion of any one part. From this circle and the first few centimetres of its branches, originate a multitude of arterioles passing to the basal ganglia and adjacent structures.

The components of this circle and their branches:

The Precommunicant.—This is a transverse branch beneath the rostrum, from 1 to 2 mm. in size, connecting the two precerebrals, and forming the anterior side of the circle. Windle found it normal in 159, double in 14, incompletely so (forked at one extremity) in 6, triple in 1, absent in 8, and associated with union of the precerebrals in 2. Wilder notes the latter condition in 6 out of 7 cases, and Starr in 2 of 14. Duret says that when double, one is of normal size, the other very small. Its place is sometimes supplied by a fasciculus of small twigs. Its branches—more numerous when the communicant is unusually long—are:

1. The *termatica*, a mesal vessel at its origin. Wilder found this present in all the 7 brains examined. "It usually divides soon into a right and left portion, which supply respectively the cinerea forming the surface of the triangular area ventrad of the genu and rostrum, and then extend around the genu to the dorsal aspect of the callosum." Windle notes it in 9 of his cases. It passed along the longitudinal fissure for two-thirds of the length of the callosum, and divided into branches supplying the opposed surfaces of the hemispheres. When the communicant is wanting, this vessel may start from the junction of the precerebrals.

2. Small retrograde rami to the gray lamina of the chiasm.

3. Arterioles which plunge into the callosal rostrum, and very often one or two considerable branches completely perforating the rostrum and ramifying on the crura of the fornix, the anterior commissure, and the septum.

The Precerebral.—This at its origin is almost perpendicular to the carotid. Often the artery of one side is larger than, and partly substitutes, that of the other side. Windle found it normal in 181 of 200 cases. In 2 the right was absent, its place being partly supplied in one by twigs from the right medicerebral, in the other by a small branch from the carotid. In 1 the right was double the size of the left; in 1 the two united to a single trunk; and in 8 they united for a short distance, six times replacing and twice accompanying the precommunicant.

The short oblique portion, dorsad of the optic nerve, between carotid and precommunicant, represents part of the circle of Willis. This portion may give off the following branches: 1. Arterioles to the optic nerve of the same side. 2. Lateral arterioles to the neighboring convolution and the callosal rostrum. 3. When, from premature division of the carotid, the precerebral goes over a longer course, it much oftener gives large twigs to the cephalon (perperforatus). Duret separated these branches into two of two courses. In one they penetrate almost within the expansion of the olfactory nerve, perforate the callosum at its junction with the lower part of the caudate head, and divide into five or six almost subequally and ramifications not extending beyond the first two rods of the constant. In the other, one or two arterioles, of about 1 mm. diameter, form a retrograde course of 3–4 mm. to the preperforated space beneath the caudate, to which latter exclusively they are distributed.

From the precommunicant on, the precerebrals run side by side around the genu and caudal in the bottom of the longitudinal fissure. After giving off the first few twigs then the main trunk may divide into three branches as noted by Duret, whose description is largely followed, or several successive branches are given off as in the accompanying plate. Together they supply the lower two-thirds of the ventral surface of the frontal lobe, the anterior four-fifths of the opposed surface of the hemisphere, the callosum (largely), and a portion of the septum. (See Plate XXXII.)

1. *Subfrontal* twigs, to the olfactory gyrus and region as far as subfrontal sulcus. 2. *Prefrontal* branch, to mesal surface of superfrontal and convex surface of superfrontal and part of medifrontal convolutions. 3. *Medifrontal* branch, to the callosal convolution and paracentral lobule. After doubling the crest of the hemisphere it terminates about the dorsal extremity of the central fissure. 4. *Postfrontal* branch, to precuneus and the adjacent portion of the convexity, rarely or quite reaching the occipital fissure. 5. *Callosal* artery. This may pass around the splenium to terminate in the pineal gland and even posterior commissure. It runs in the callosal convolution and runs along, perforating the latter and ramifying over the whole extent of the roof of the paracoeles.

The Cerebral Carotid.—As a rule the postcommunicant is a direct branch of the carotid, though it often starts from the medicerebral. In the former case the carotid, from this branch to its termination at the commencement of the Sylvian fissure in the perforated space, forms part of the circle of Willis. In this short course a few lateral branches are given off.

1. Arterioles to the external angle of the chiasm. Either these or the *chiasmal* arterioles from the precerebral supply minute twigs to the first portion of the optic nerve. 2. Frequently, one or more of the *perforantes* to the caudate. 3. *Postchoroid.* This may come from the medicerebral or even from the postcommunicant; in any case its origin is peripheral to that of the last named. It is directed obliquely caudad along the outer side of the optic tract to attain the choroid plexus in the lateral horn (through the extremity of the transverse of Bichat's fissure). It gives off *a*, internal and slightly recurrent branches to the optic tract; *b*, internal branches for the central part of the outer aspect of the crus cerebri; *c*, external branches to the uncus (a terminal arteriole, Heubner); *d*, extremely fine twigs to the two tubes of the choroid plexus, that it is stated to traverse.

The Medicerebral.—The vessel represents the most direct continuation of the cerebral carotid. It lies at the bottom of the Sylvian fissure, as do also the primitive portions of its larger branches as they spread out over the insula. When the postcommunicant starts from the medicerebral, the previous short (4–6 mm. long) portion of the latter participates in the circle of Willis. No branches are assigned to this part.

The medicerebral in its further course yields two classes of branches: *a*, direct, perforating, or nutrient arterioles; *b*, large and small pia arteries.

a. A few perforantes from the earlier part of this artery may pass directly to the caudate head, with those described under precerebral and mentioned under carotid. But the main group from this source take a somewhat different course, and, as stated by Heubner, are often detached from the trunk farther out in the fissure. These have been divided into two sets. The first to leave the trunk—*lenticular arteries*—are the finer, and are similar in department to the preceding, except that they go to the first and second segments (apex) of the lenticular nucleus. The second, coarser set runs along the base of the lenticular nucleus on the inner of the external capsule. A portion of these pass caudad and dorsad to the thalamic extremity of the lenticular nucleus and terminate in the thalamus—*lenticulo-thalamic arteries*. One arteriole, uniformly larger than any of the others, and the frequent source of hæmorrhage in this region, passes dorsad and mesad to the third segment of the lenticular, where it gives off many side twigs, and finally divides into four or five terminal branches, supplying also the adjacent internal capsule, etc. Two or three accompanying arterioles extend toward the third segment, and may attain the tail of the caudate. Collectively these are termed *lenticulo-striate arteries*.

A further group might be made of the small direct vessels traversing the insula to gain and supply the claustrum; as this is, however, a derivative of the external gray layer, these twigs more nearly correspond to the general cortical and allied arterioles.

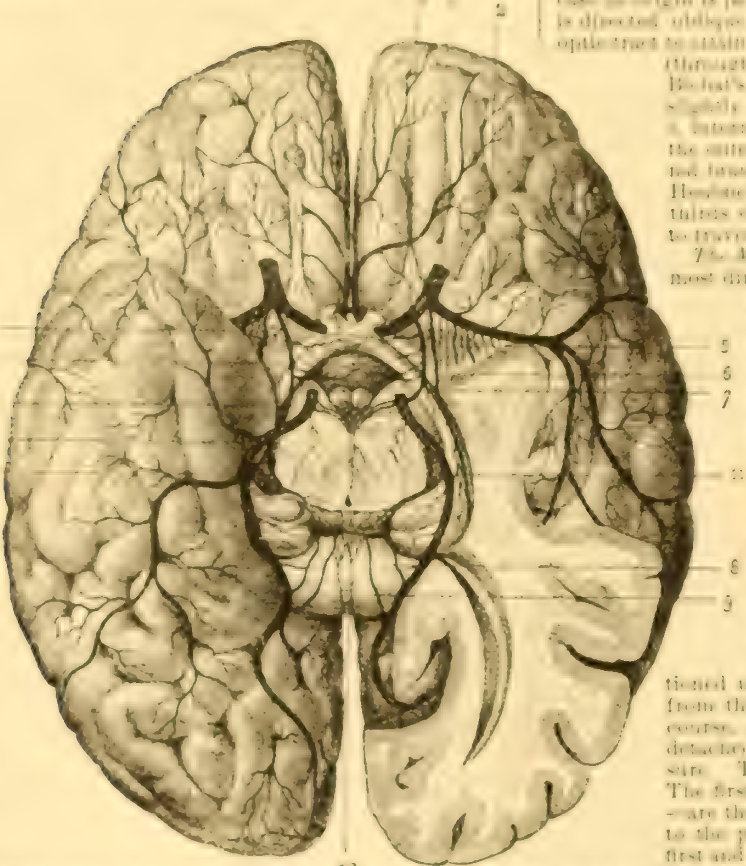

FIG. 889.—Arteries of the Base. (After Duret.) 1, Carotid; 2, medicerebral; 3, precerebral; 4, postcerebral; 5, [illegible]; 6, [illegible]; 7, precommunicant; [illegible]

Of the perforantes as a whole, it may be said that they all emanate at right angles from the inner side of the mother vessel. Their size varies from ½ to 1½ mm. They immediately enter the brain substance, only occasionally dividing, and never anastomosing before doing so. They usually run a further short course before branching. The ultimate distribution of each is pencil-shaped. They are destined to supply the central gray nuclei and the capsules, notably the inner. They are all true terminal arteries, without any anastomoses either between themselves or with other arteries. According to the French school, even their finest capillaries do not connect, but on this point the Germans teach otherwise.

b. Pia-branches of the Medicerebral.—After a course of 1 to 2½ ctm. the main trunk, either at one stroke or successively, divides into several large branches. 1. Previously, however, there are usually a few small rami for the adjacent borders of the frontal, and especially the temporal, lobes. (See Plate XXXII.)

2. *Frontal* branch. This is generally the first large ramus. Like the succeeding, it runs some distance deep in the sulcus and subdivides often, at least before appearing externally. It is especially destined for the subfrontal convolution. It supplies the orbital surface of the frontal lobe external to the orbital fissure, and the convexity dorsad to the middle of the medifrontal gyrus, caudad to the precentral sulcus. Duret found a very constant corresponding artery in several species of animals.

3. *Preparietal.* This nourishes the precentral and adjacent extremity of medifrontal convolutions, and may by an early branch include the postcentral also.

4. *Mediparietal.* This may gain the fissure of Rolando to supply not only the postcentral convolution, but dorsad a portion also of the precentral. It may also reach the adjacent parietal region.

5. *Postparietal.* This is a large branch in the horizontal Sylvian fissure. Its ramifications do not extend beyond the parietal or occipital fissure, but may pass beyond the supertemporal.

6. *Temporal.* This is included under the last by many, but it is often an early and large branch of the medicerebral. By its numerous considerable subdivisions it then covers practically the whole external temporal surface. At least the supertemporal convolution and much of the meditemporal are regularly supplied. Its distribution extends nearly to the suboccipital convolution.

There is no special artery for the insula, but it receives several small branches from the preceding as they cross it.

The Postcommunicant.—Connecting the pre- and post- (carotid and vertebral) systems. They start from the carotid or medicerebral, and run directly caudad to inosculate with the corresponding postcerebral at 5-12 mm. from the latter's origin. They pass ventrad of the optic tracts and also encounter the crura cerebri. In size and occurrence these vessels are variable, and frequently unsymmetrical. The left is more often the smaller or even absent, though some filiform anastomosis from a corresponding branch of the carotid usually does exist. As a very large branch from the carotid, especially the right, it may replace the corresponding postcerebral wholly or in part, or conversely; a large left communicant has been observed to arise from the postcerebral and supply the same medicerebral. Aside from disparity in size (43 times) the postcommunicants were normal in 175 of Windle's cases. Excepting slight anastomosis, both were absent in 3 cases, the right in 9, the left in 13. In 7 both were very small; in 28 the right was much larger than the left; in 15 the reverse.

This vessel gives off laterally pia-branches, (*a*) internal, (*b*) external, and (*c*) inconstant penetrating rami.

a. 1. Chiasmic branches to the caudad side of the chiasm. 2. Twigs to the tuber cinereum and infundibulum, a descending ramus supplying the pituitary body. 3. Two to the mammillary bodies.

b. 1. To the optic tract. 2. To the cerebral crura. 3. Often considerable branches to adjacent temporal gyri.

c. 1. *Prethalamic artery* (internal and anterior optic of Duret). It penetrates between the tuber cinereum and mammillary bodies, and ramifies in the more anterior part of the aula, on the walls of the infundibulum, etc. 2. Medithalamic artery (posterior internal optic). At times large, it enters the postperforated space and passes directly dorsad near the inner thalamic wall, to which and the gray commissure it is distributed. This vessel comes as often from the postcerebral as from the postcommunicant. The prethalamic may also have the same origin.

The Postcerebrals, from the end of the basilar to the postcommunicants, complete the circle of Willis. This part furnishes: 1, three or four arterioles to the internal aspect of the crura cerebri, supplying its basal layer, the locus niger, etc.; 2, little branches entering the thalamus through the postperforated space. These accompany, and often include, the above-described medithalamic artery.

Windle found the postcerebral arteries normal in 173 cases. The vessel was derived from the carotid instead of the basilar in 11 cases on the right, 9 on the left, and 4 on both sides. There were 2 postcerebrals on the same side—the smaller from the basilar, the larger from the carotid—in 3 cases, 1 on the right and 2 on the left.

This trunk, in passing around the crus, describes a kind of semicircle, directed toward the transverse fissure. Dorsad of the crus, at about 1 ctm. from the optic lobes, it turns latero-caudad to gain the calcarine fissure, where it breaks up to supply the basilar postcerebral region. From its crural portions it supplies, besides other branches, nearly all the nutrient arteries of the cœlian walls.

1. Little twigs to the outer part of the crus, penetrating almost immediately. Instead of several in the thalamo-crural sulcus, there may be a single larger one, parallel to the main stem.

2. The fairly constant *medioptic* (median quadrigeminal), giving fine offshoots in its course to the crus, and terminating in a bunch of fine vessels in the interval of the optic lobes.

3. *Postthalamic* (so-called posterior and external), two or three, or a single larger one, starting midway from this portion of the postcerebral, and following the crus to enter the thalamus between the geniculate bodies.

4. *Geniculate*, emanating directly, or from the thalamic.

5. *Postchoroid* (posterior and lateral), starting near the optic lobes, and entering between the layers of the velum. It always divides into two principal rami: a lateral one for the third of the choroid plexus not supplied by the prechoroid artery, *i.e.*, for the plexus over the thalamus; the other more median one for the velum (*ramus velaris*).

6. *Medichoroid* (posterior and median choroidal), from the postcerebral at its nearest approach to the median line. It courses beside the conarium, to which it yields some rami, and immediately divides into two branches, one to the velum of the aula, the other exclusively to the choroid plexus of the same cavity.

The choroid plexi and velum represent a double layer (fold) of the pia, within which the cœlian arteries and veins course. Duret states that in all the cœles the arteries to the velum are distinct from those to the plexus, often even from their origin at the postcerebral, and always at their entrance into the corresponding cavity, and that they never mingle in their distribution. From the velar arteries are detached a multitude of little arterioles, which penetrate the thalamus 1 to 1½ ctm. They have the arrangement of cortical arterioles, and are penicillated. The two velar branches terminate in the head of the caudate, either simply subependymal or passing deeply into its substance. The velar branches to the aula emit little arterioles laterally at intervals of about a millimetre. These penetrate perpendicularly the adjacent wall. They supply also the posterior and gray commissures, and terminate in a fine pencil in the anterior commissure. The plexus arteries, on the contrary, do not usually participate in the nutrition of the cœlian walls. They divide into four or five long parallel branches from which little arte-

[illegible] pass into the plexuses, properly speaking. They enter the villi, by their base, and form very sharp-bent and continuous capillary meshes. It has been suggested that they are the remains of former branches ramifying in the embryonic surface pia, and that they became coiled as [illegible] this [illegible] [illegible].

7. *Posterior anterior quadrigeminal*, very short, coming from the most median part of the postcerebral, or from some branch of the latter. It forms a very delicate plexus over the geniculate body. This makes the third possibly [illegible] part of [illegible] arteries, as these latter are very [illegible]. They have some anastomoses across the median line.

8. Artery of the [illegible]. Sometimes offered from some branch of the postcerebral than arising directly. It does not ramify on the median surface, but passes between the hippocampus and the [illegible] convolution to the [illegible] in the manner of external arteries.

9. Variable branches to adjacent temporal gyri.

Three Branches of Postcerebral.—[illegible], be brought under three general heads (see Plate XXXII.):

1. *Temporal* branches to the uncus in part, and the basal surface of the temporal lobe as far as the border of the convexity, except the third nearest the apex of the lobe, which is supplied from the medicerebral.

2. *Post-temporal* to the basal surface of the occipital lobe, including a variable amount of the adjacent temporal region, and climbing the border of the convexity to supply a little of the external occipital region. The hippocampus may be supplied from the parent stem, or from either 1 or 2.

3. *Occipital artery.*—This runs along the calcarine fissure, sending a large branch through the occipital fissure. It supplies the cuneus and general median surface of the postcerebral lobe, and a considerable strip of the adjacent occipital convexity. Spitzka says that an artery large enough to cause fatal hæmorrhage enters the gray and white of the right occipital lobe.

General Features of the Arterial Supply.—The distribution of each primary trunk includes: *a*, basilar or nuclear branches; and *b*, pia or cortical branches. *a*. These are the pre- and post-perforating and median arteries, arising in part from the circle of Willis. They supply the central ganglia, median structures, and in part the centrum semiovale. To the same class belong the direct arterioles from the basilar to the nuclei in the pons. Excepting occasional and unimportant anastomoses these are all true terminal vessels. They divide within the brain-substance at an acute and not a right angle. *b*. The pia branches or divisions as described are only averages, complementary variations therefrom always being present, though it is claimed that while "their origin is often very variable, their distribution is constant." The larger arterial trunks correspond to the main fissures. To a marked extent it is true that the same branch does not supply both sides of a sulcus. Branches usually leave the parent stem at almost or quite a right angle. Some writers try to show a freer supply to the left hemisphere. Duret's attempted correlation of arterial distribution and physiological function was at least premature (1874) and faulty.

Anastomoses.—The basal circle of Willis comprises all the communications readily demonstrable on the uninjected pia arteries of the cerebrum. Only within this circle and over the outer lobes are there any minute connections across the median line of the hemispheres.

There has been a dispute as to the extent to which the ramifications of adjacent branches on either hemisphere are connected. Duret, after numerous, varied, and evidently careful examinations, says: "Never have we found an anastomotic network in the pia." He also notes the frequent superposition in the pia of the arterial ramifications. Nevertheless he found considerable individual differences, and regularly found fine (1/4 to 1/2 mm.) communications, especially at the periphery, i.e., between adjacent territories of distribution. On p. 317 he expressly states that in the great majority of cases, owing to anastomoses, "extremely fine and unimportant," softening from occlusion of any of the large basilar trunks spares the peripheral parts of the artery's territory. In the four-months fœtus he found abundant fine anastomoses. Heubner (p. 170), on the contrary, says: "The chief (pia) branches end in a kind of communicating canal system or passage, which is spread out in the shape of a tubular net over the whole surface of the brain." By injecting "under weak fluid-pressure" he found plentiful anastomoses up to 1 mm. in diameter. Heubner's description harmonizes with that of older writers, and is corroborated by Lucas, who by sufficiently penetrating injections was able to demonstrate an abundance of communicating arterioles up to 1/2 mm. It remains true, however, that when the communicants of the circle of Willis are poorly developed, the peripheral anastomoses are in a large majority of cases incapable of substituting them.

Brain-Nutrient Arterioles of the Convolutions.—These emanate at right angles from the pia branches of all sizes. They penetrate the crests of the convolutions perpendicularly, the inclined surfaces obliquely. They are innumerable, scarcely more than a mm. apart. According to size and distribution there are two classes:

1. *Cortical*, 0.05 to 0.08 mm. in diameter. The finer stop in the cortex proper; the others go to the boundary of gray and white. The capillary net-work from these rami has been divided into three somewhat differently characterized layers, each parallel to the outlying surface.

2. *Albal* (arteriolæ longæ), 0.08 to 0.14 mm. in diameter. These are almost rectilinear, can be followed a distance of from 3 to 4 cm., and branch at an acute angle. They supply a considerable portion of the centrum semiovale. One often passes down along the axis of the convolution. A group of five or six at the bottom of a fissure (in section) converge on entering. The capillary net-work of the albals is more elongated than that of the corticals and accompanies the fasciculi of nerve-fibres.

Both classes anastomose freely in their finer branches though in general penicillate.

From the anatomical arrangement it is believed that the intravascular pressure is less in the gray than in the white substance.

It has been claimed by many that the thyroid gland acts as a safety diverticulum to the cerebral supply; and, furthermore, that the lack of this regulator explained the occurrence of so-called cachexia strumipriva after removal of that gland; but any such special function of the thyroid is at least not proven.

Veins.—The venous passages of the brain and its membranes include:

I. The dural veins.
II. The intrinsic veins, or those of the brain proper.
III. The sinuses.
IV. The venous exits from the skull.

All the intrinsic and most of the dural veins discharge into the sinuses, or [illegible] spaces, which in turn convey the blood to the exits. Otherwise these two sets of veins are separate systems, not intercommunicating, unless occasionally near their mouths. The intrinsic veins without exception have thin, readily collapsing walls, while the sinuses are held open by the firm enclosing dura. In general it may be stated that *the walls of all these vessels are devoid of muscular elements*, though occasional unstriped fibres have been observed in the intrinsic veins. From this absence of actively contracting fibres it follows that these vessels play a merely passive rôle in the encephalic circulation. The encranial veins, like the external veins of the head, are devoid of true valves. However, at the orifices of the diploic veins (Dupuytren, Langer, doubted by Trolard) and in the ophthalmo-facial vein, valves may occur. It has also been claimed that the superficial veins in part present a valve-like arrangement at their discharge into the longitudinal sinus. The general impression that valves do not occur in any of the veins above the common jugular is, therefore, correct.

I. Veins of the Dura, including those of the diploë.—These are many in number, but all of small size. They anastomose so freely that they might almost be denominated a plexus. In position they are comparable to the plexus venosus existing between dura and periosteum of

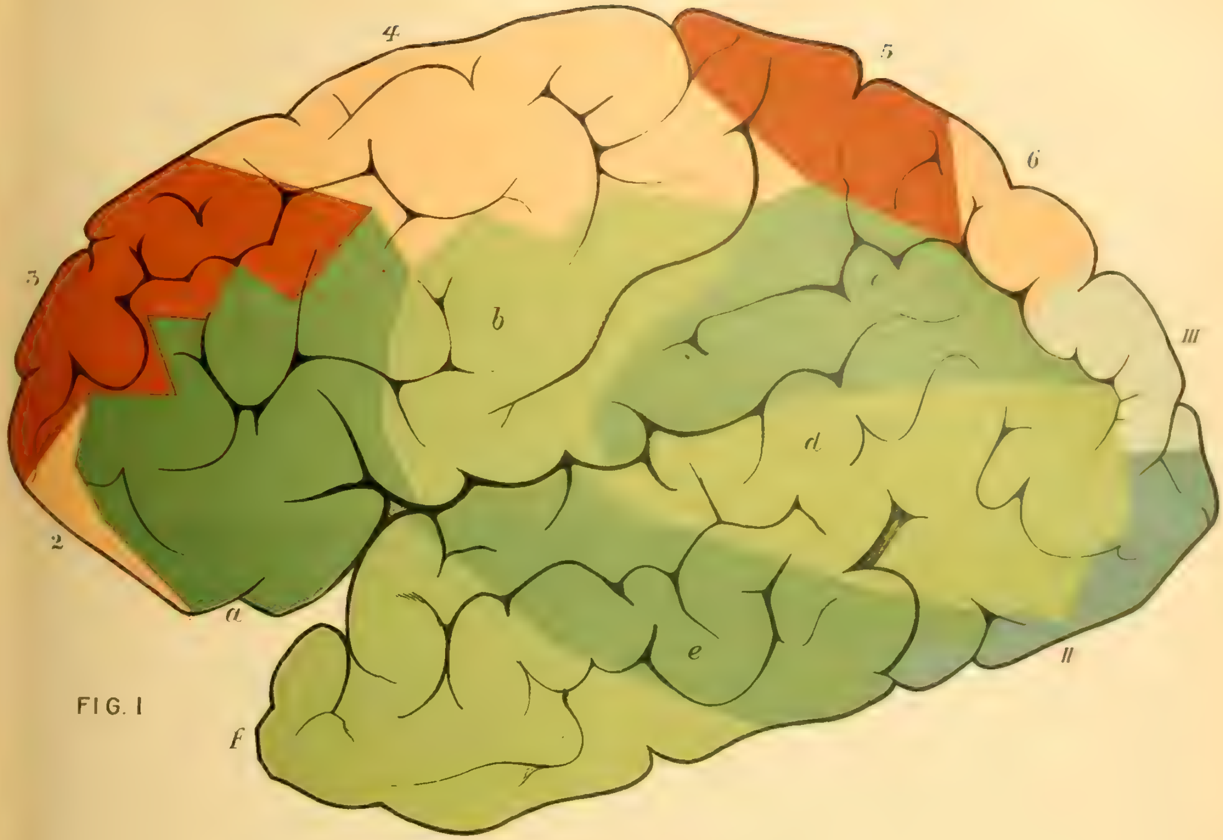

FIG. I

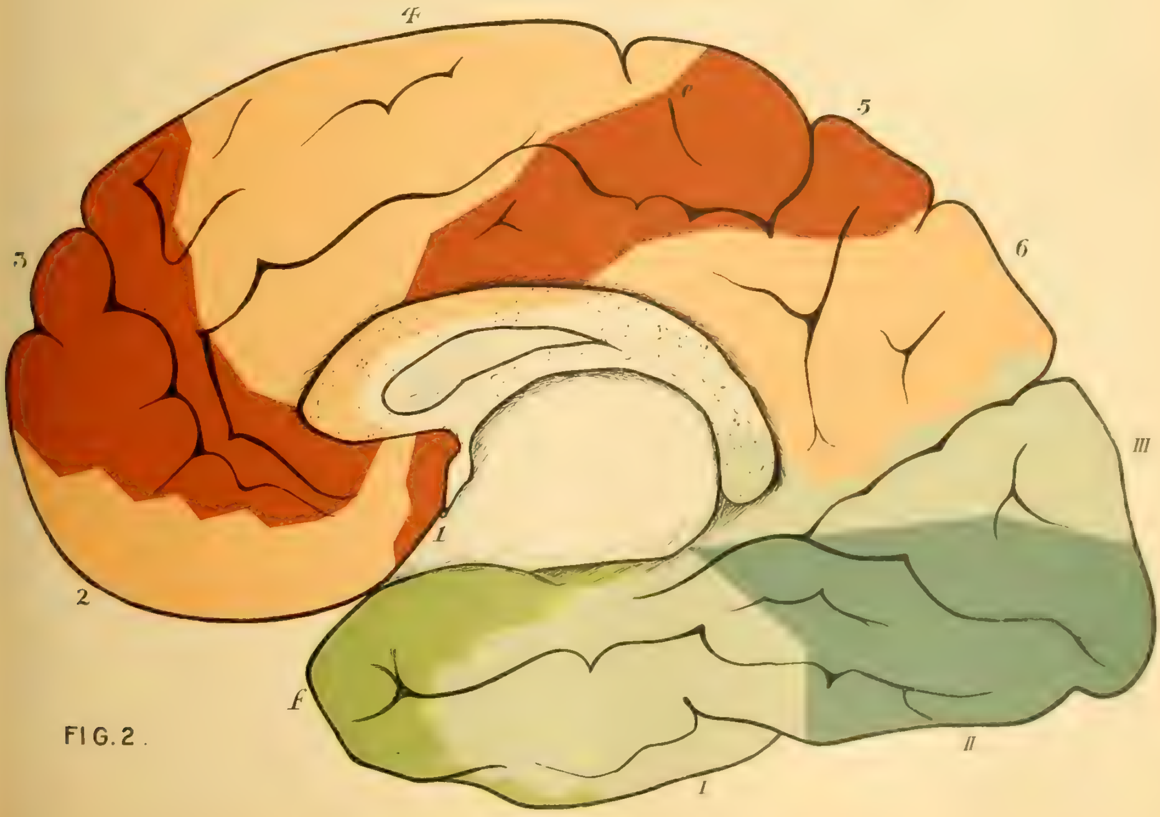

FIG. 2.

Arterial Distribution over Convexity (Fig. 1), and Mesial Surface (Fig. 2): Precerebral in Brown: Medicerebral in Green: Post Cerebral in Blue. Branches indicated by Shades of the Primary

the spinal canal. In their ultimate distribution they form two vascular nets, according to Langer, one in the outer, the other in the inner, layer of the dura. The beautiful, almost regular, interlacing of the former, figured by Langer from the fœtus, the writer is able to corroborate. By means of small veinlets penetrating the inner plate of the skull, the dural veins communicate extensively with those of the diploë. They include:

1. *Medidural*, or *Venæ comites*, accompanying the medidural artery and its branches. The two on either side of an artery repeatedly connect with each other and with neighboring veinlets. The largest pair is about the common trunk of the artery. One of these passes externally through a basal foramen to the pterygoid veins. The other ends in the medicerebral vein or its temporal sinus, or directly in the sphenoidal or cavernous sinus, with which latter it usually at least connects. The diploic canals have some special openings into the larger medidural veins.

2. *Superdurals.* These appear in part as direct continuations of the preceding, and then are double. They pass to the longitudinal sinus, largely through the intermediation of its lateral spaces. Labbé suggests that the supra- and medi-dural veins may constitute a small collateral path between the long sinus and basal conducts.

3. *Falcial trunklets* (Fig. 4882, *k*), running to the longitudinal sinus and to the falcial sinus when present, otherwise to the tentorial. The tentorials go to the lateral and tentorial sinuses, also in part by way of the parasinual spaces.

4. The numerous veinlets for the other dural arteries, *e.g.*, in the occipital fossa, have a more independent course and end in adjacent sinuses.

Venous canals of the diploë, even less yielding than the sinuses. Breschet's description is somewhat modified by Trolard. The diploë is made up of little areolæ. These canalize in any direction, though in general ventrad to discharge near the base. These canals are quite unsymmetrical, and do not increase in size in their course, excepting where there are casual enlargements; areolæ, conduits, and lacunæ are lined with a smooth membrane. Generally the diploë begins to appear about the tenth year, though small straight veins are evident earlier. Resorption of the cancelli goes on continuously, and after fusion of the sutures they may pass from one bone to another. In the aged we find a sort of wide-spaced venous plexus, no longer canals. There are several exterior outlets and numerous interior ones. Even the one through the supraorbital notch passes to the ophthalmic vein and so to the cavernous sinus. Casual mention will be made of most of the special terminations.

II. VEINS OF THE PIA AND BRAIN SUBSTANCE.—From their derivation and discharge, these vessels naturally fall into three classes:

A. The supercerebrals, passing to the longitudinal sinus. B. The internal or Galen's system, tributary to the tentorial sinus. C. Basal veins, ending in the various sinuses of the base.

A. The *supercerebral* veins return the blood from the convexity as far as the Sylvian fissure, and from the median surface of the hemispheres as far as the supercallosal fissure. There may be a slight interval between the frontal set and the others, or a smaller vein may here occur; otherwise they are all fairly equidistant. There are usually six to eight large trunks on each side. These veins tend to empty into the sinus in pairs. This is less marked in the frontal set. It is most easily demonstrable in the fœtus, owing to the absence of Pacchionian bodies, or thickening, adhesions, etc., at the border of the convexity. The last pair ends in the sinus some three to five centimetres before the torcular. The second or third pair from the last may be somewhat larger than the others, and then represent the so-called anastomotic vein, though its size is quite as much due to the greater width of the brain in this part. Although Labbé says this vein runs along the postcentral fissure, it is probably identical with Krause's fœtal *vena sulci centralis.* Moreover, each supercerebral vein is double, also best seen in the fœtus. The two constituent veins are of unequal size, the larger external one coming from the convexity, the smaller inner one coming from the median surface (of hemisphere). They may soon unite to one trunk, but generally, in their further course to the sinus they lie side by side within a common sheath, and do not lose their integrity as independent conduits until about to open into the sinus. Commonly some of the paired, as well as their constituent double veins, are wanting to complete the diagram.

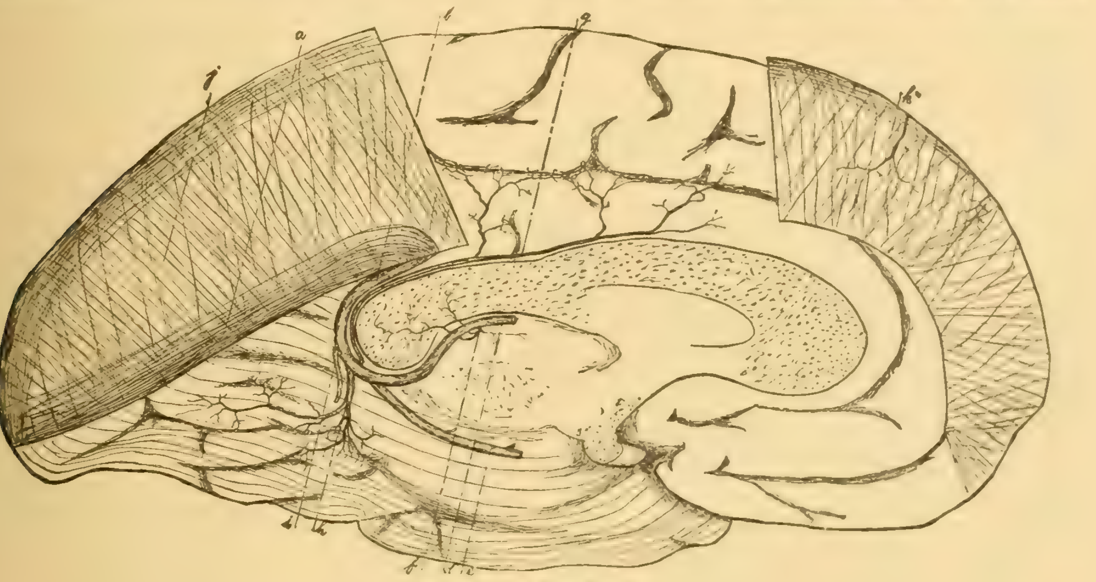

FIG. 4882.—The Vena Galeni.

The frontal set take a course very nearly at right angles to the sinus, or the first of them may even run caudad along the sinus before discharging. They usually spring over to the dura a couple of centimetres away from the sinus. Farther along the sinus the veins take a more and more oblique course until they at last run forward a distance of three or four centimetres, to discharge against the current. At the border of the convexity, or farther out in the pia, the vein makes the necessary bend to approach the sinus as described. It then runs a short distance in the pia, becoming in the cortex a free trunk, for a further short length, and finishes its course in the sinus.

Again, the frontal are open at the lateral angle of the sinus, while the others open more and more at the side, and the last quite at the bottom of the sinus, even coming up a distance towards the face.

Toward their field of derivation these trunks pursue an insufficiently grouped course. In general, over the cortical area the finer radicles are fairly distributed everywhere, from the bottom of the fissures to the crest of the convolutions.

II. *The Internal System, Tributary to the Tentorial Sinus.*—Along its course this small sinus receives only unimportant, mostly dural, venules. At its commencement there may be two affluents: *a*, the basal sinus; *b*, the vena Galeni.

a. The important *basal sinus* also receives only dural twigs in its course, but at its commencement, opposite the frontal border of middle third of callosum, could take up a small vein or veins coming from the frontal third of the callosum, and from the bordering convolutions. Labbé calls this the interhemispheric vein, and says that the case is the continuation of a venule bifurcating, sending a branch to either side. A parallel term, precallosal, was given by Breschet to the precerebral vein.

b. *Vena Galeni.*—This discharges through a slit in the basal wall of the sinus, just caudad of the free border of the tentorium. The name is now limited to the short (1 cm. long, 6 mm. broad) trunk from the union of the velar veins to the sinus. Within, it is often divided by a longitudinal septum.

The course of Galen's vein and the adjacent portion of the velars is very peculiar. The vessels sink a little after crossing the optic lobes, then encircle the splenium, and become subtentorial before ending in the sinus. The latter bears the relation thereto of a tangent to a circle (cf. Fig. 4882).

Galen's vein does not usually receive any lateral affluents. It arises from the union of the right and left velar veins. Each of these consists of two portions, a terminal bent part (*portio curvata*, Fig. 4883, *c-e*) from the entrance to the vena Galeni, and a peripheral, or caudad straight part (*portio recta*) from the origin of these veins opposite the foramen of Monro. The two curved portions start and end together, but midway diverge 0.5 cm.; they receive laterally many large branches. The straight portions run parallel and adjacent, but receive only few and small additions.

The affluents to the portio curvata are largely of cortical origin: 1, v. suboccipitalis; 2, v. supercerebellaris; 3, v. callosalis; 4, v. subcerebralis; 5, vv. optici et conarii; 6, v. postcornualis.

1. The *suboccipital vein* (Fig. 4882, *h*) comes from the collateral fissure and median portion of the suboccipital surface of the cerebrum.

2. The *supercerebellar vein* (Fig. 4882, *k*), oftener a single trunk, but occasionally bilateral, empties into the main vein near its termination, or even directly into the sinus tentorialis. It starts from many little branches over the dorsal surface of the cerebellum, the supervermis, and in its further course takes up small veins from the crura cerebri, and at times also from the optic lobes.

3. The *callosal vein* (Figs. 4882 and 4883, *g*) (first mentioned by Labbé, 1879, then independently described by the writer in 1884) may be either single or bilateral. It is a small but long vessel, and the only one emptying on the concave side of the portio curvata. Its origin is near the middle of the callosum, and dorsad as far as the callosal fissure. It runs caudad at the bottom of the longitudinal fissure, and curves around the splenium close to Galen's vein. In animals (sheep) its size almost equals that of Galen's vein.

4. The *subcerebral* (Fig. 4882, *e*) is a large vein, though its derivate territory is very variable. It forms by the union of many branches—collectively termed *prebasal veins*—opposite the preperforated space. The prebasals include the first five next following:

1. The *precerebral* vein takes nearly the same path, but is too small and uncertain to be well compared to the precerebral artery. Its derivative area is very small, less. It comes around the genu to the base, where it passes before the chiasm to the subcerebral vein. The right and left are usually of unequal size, but communicate, though by an insignificant branch compared to the arterial precommunicant. The two veins may anastomose before the chiasm and pass to one of the subcerebrals, in which case there are one or more slight connections in front of the chiasm with the other subcerebral vein. This vein receives branches from the genu and adjacent median frontal surface.

2. The *olfactory* is a tiny venule, very constant, and demonstrable as far as the olfactory bulb.

3. *Suprafrontals.* One of these is frequently more developed, and may empty instead caudally into the Sylvian or the mediocerebral vein.

4. The Sylvian vein is a variable complement of the mediocerebral venous system. *It lies at the bottom of the basi-Sylvian fissure*, covered up, except near its termination, by the tip of the temporal lobe. It arises in the region of the insula from a great number of radicles. When the mediocerebral is poorly represented the Sylvian may take up twigs from the surface of the temporal and frontal lobes. Around the venae perforantes pass, as a rule, to this vein. There is here often a group of perforantes separated from the others and coming from the lenticular substance caudad of the vessel.

5. The *venae perforantes* are small, very variable in number, and take a straight course for a short distance before splitting up. They come from the striate body and adjacent frontal alba. Their radicles approximate those of the precentral veins, yet without observable anastomoses.

6. The subcerebral vein receives, in its course obliquely across the optic tracts and crura cerebri, several small venules from the chiasm, infundibulum, mammillary bodies, crura, etc. These anastomose freely with each other, and with those of the other side, thus making an outstretched network over these parts which connects on the one hand with a small network before the chiasm, and on the other with that across the pons. This corresponds in general to what Labbé terms the inferior interhemispheric veins. Frequently there are accessory venules from the basal temporal surface.

7. The *subcornual* vein, in that it comes from the end of the middle horn, is comparable to the prechoroid artery. It is very constant in occurrence, but not in size. Though connected with the choroid plexus of the medicornu, it originates in the cerebral substance, sometimes even from the lateral wall of the postcornu, almost opposite the caudal border of the thalamus, where branches are received from the alba lateral to the thalamus or from other directions. In its course along the lateral wall of the horn it receives many accessories, notably from the cornu Ammonis, and as it curves around the end of the horn several twigs from the alba of the temporal apex.

8. *Postperforants*, at least one considerable venule.

9. *Crural* branches, one in particular, can be followed along the crus to the cerebellum.

5. The *bigeminal* vein and variable *optic* twigs often end in the supercerebellar vein instead of directly in the velar. They originate in a fine venous plexus over the optic lobes and conarium, which appears to be connected across the crura cerebri with the basal network described above.

6. The *postcornual* vein is variable, complementary in derivation to the subcornual. It may arise in the alba near the tip of the occipital lobe, and then runs subependymal along the cornual wall. The parathalamic branches above ascribed to the subcornual, and some from the Ammon's horn, pass often in part to the postcornual. The radiate radicles of this vein are traceable through the alba nearly to the cortex (Fig. 4884, *q q*).

There is frequently another vein intermediary between 7 and 6, emptying into either the subcornual or the postcornual.

The straight portion of the velar vein in its course through the velum receives the following, all at right angles:

1. The *splenial* veins (Fig. 4882, *f.*) are very small, and but two or three in number as they come out through the fornix. They often combine with thalamic radicles and empty as one trunk into the velar.

2. The *thalamo-crural* vein, usually one on each side, but sometimes multiple (Fig. 4883, *m.*, *m.*). This begins about the cerebral crus, makes its way dorsad and mesad through the thalamus, and joins the portio recta at about its middle point. It approaches the ventrad side of the velar, and hence is but too easily overseen. Neither 1 nor 2 runs any length in the velum.

3. The *thalamic* veinules are very variable in size, number, and position. They may even be entirely wanting, or run to neighboring veins, *e.g.*, the postcornual. These only arise to a limited extent in the thalamus; they come chiefly from the albalis beyond, running across or a trifle embedded in it. Where one of these is specially large it might be termed the *transthalamic.*

Opposite or toward the apex of the thalamus, the velar vein is formed by the immediate or mediate union of several small trunks. Most of these are in a cluster coming in laterally between thalamus and striatum; the latter nucleus appears much richer in veins than the former. Of all but the first, the intracœlial course of these veins is subependymal.

1. The *medicornual* vein (Fig. 4883, *l.*) takes a sinuous course in the outer edge of the choroid plexus, of about double the actual distance. Its membranous envelopment makes it a counterpart of the pia-veins, and hence the actual continuation of the velar, as held by Bell. It begins in the middle horn, where it is said to anastomose with the subcornual. It comes out of the horn with the plexus, bends to follow the lateral thalamic border, and ends in any one of the veins near the commencement of the velar. Meanwhile it receives a multitude of radicles from the plexus, and some that seem to come from the surface of the thalamus.

2. The *tænial* vein comes from the thalamo-striatal groove, beneath the tænia. Nevertheless it has few tributaries from the thalamus. This short trunk is made up by three sets of veinules: (*a*) *Striatal.* Of these there are usually two or three larger and several smaller branches, coming from the substance and surface of the caudate, and passing to the tænial trunk or to either of the following: (*b*) A prealbal trend of veinules, passing along the outer cœlian border toward the precornu, and thence largely to the albalis of the frontal lobe. (*c*) An opposite trend, directly caudad, a short distance along the outer cœlian wall, and coming from the lenticular nucleus, the internal and external capsules, and the superimposed portion of the centrum semiovale. Many of these various albal radicles can be followed almost to the cortex; their angles of union are acute.

3. The *paraseptal* trunk (Fig. 4883, *o*, *o*). This short vessel, with its two constituent *precornual* veins, is the most direct continuation of the velar. Laterally it receives small *septal* and *genual* accessions. There are usually two parallel precornuals (*pp*). They come from the extremity of the horn and follow its contour around to the septum, or run in the adjacent border of the caudate, though they take up no important radicles from that nucleus. Their multitude of radicles come from the albalis in the basal portion of the frontal lobe, also demonstrable nearly to the cortex.

4. The *superalbals* (Fig. 4883, *nn*) are commonly two small trunks that appear at the outer border of the cœle, opposite the body of the caudate, cross the latter, and empty through the tænial or paraseptal trunk. They come from the cœlian roof, and the frontal and parietal albalis dorsad of those previously described.

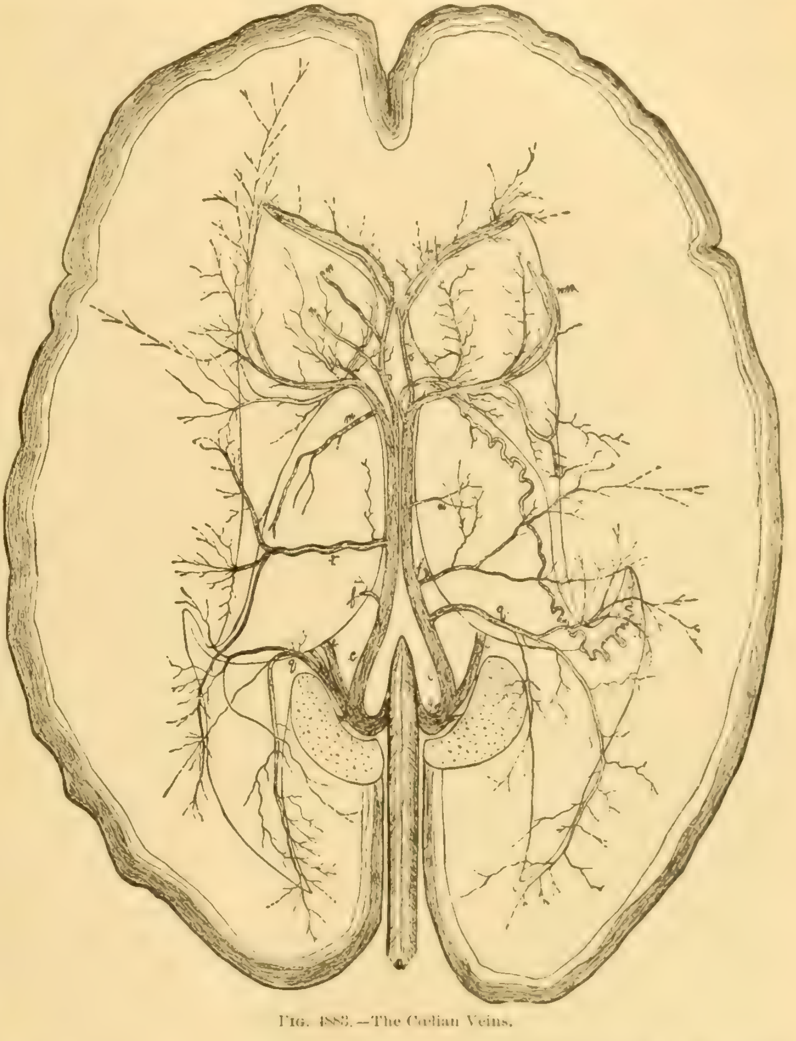

FIG. 4883.—The Cœlian Veins.

C. *Basal Veins.*—These do not constitute a system in the sense of having a common point of discharge—in fact, they have already been described in part under Subcerebral Vein. Although they are quite irregular in termination—small veins seem occasionally to end at any point in the basal sinuses—still there are four frequent points of discharge: 1, Cavernous (and sphenoidal) sinus; 2, superpetrosal sinus; 3, middle of lateral sinus; 4, some sinus about the foramen magnum.

1. Some small veins from the pituitary body and other structures about the sella turcica have been described as tributary to the vene-circle of Ridley. But the largest vein discharging at this point is the *medicerebral*, a superficial vessel following the Sylvian fissure. This should be distinguished from the smaller though complementary

Sylvian vein running at the bottom of the fissure. The medisagittal is inclined to be double, i.e., there are sometimes parallel adjacent veins, one taking up frontal branches, the other only temporal. In this case one vein may receive some of the branches above described and empty into the sphenoidal or the cavernous sinus, while the other vein, accompanied by the dura across the temporal fossa, to the middle of the superpetrosal sinus. This latter is the course that the Sylvian medicerebral vein takes in many cases, as Trolard rightly says; the deep portion may be termed the temporal sinus; by one or two lateral affluents it communicates with the meningeal veins which it crosses.

2. The discharge of the subcerebral vein through the vein of Galen, as given above, holds for about one-half the cases, not always alike on the two sides. The main trunk may be diminished by the termination of some of its usual proximal constituents in the cavernous sinus or medipeduncular vein. Whether larger or smaller, the trunk in others passes to a basal sinus (superpetrosal) by turning ventrad instead of dorsad on reaching the cerebral crus.

One or more precerebellar veins from the flocculus region pass to the superpetrosal sinus, with the subcerebral vein, when this terminates at the base; otherwise they seem to connect with this by venules along the lateral surface of the cerebral crus.

3. The postcerebral veins usually unite into one trunk just at the point where, turning caudad, they form an ampulla in the dura and enter the sinus. This is at the lateral border of the occipital fossa, opposite the exoccipital fissure. These veins come in part from the convexity, in part from the basal surface of the occipital lobe. The latter may be single or multiple; their derivative area is lateral to that of the suboccipital vein. The former is represented by one large trunk from the direction of the Sylvian fissure; it receives varying temporal branches and large ones from the external occipital surface. The postcerebellar veins are smaller than the postcerebrals, but often empty opposite them, though, of course, subtentorial to them. They come from the lateral portion of the cerebellum. The very inconstant postcerebellar veins, one or more in number, terminate in the lateral sinus near the torcular, or even in the tentorium.

4. The subcerebellar veins include only small vessels at the bottom of the posterior fossa discharging into the occipital sinus.

The cerebellar veins—supra, pre-, post-, and sub—are but partially distinct from the cerebral veins.

GENERAL FEATURES OF THE INTRINSIC VEINS.—*Communications.*—In this regard the pia veins must be distinguished from those of the brain substance. In contrast to the arteries, the pia veins communicate freely, not only indirectly through the sinuses, but everywhere on the surface by a network of small vessels, as well as frequently by anastomoses between larger trunks. The veins of the convexity might almost be said to radiate from the Sylvian fissure (horizontal Sylvian). At least several of the larger ones connect toward the middle of the convexity. Of these four may be specified: 1. One of the frontal supercerebrals (fronto-dorsal); 2, the second or third from the last supercerebral (caudo-dorsal); 3, the external trunk of the postcerebral (caudo-ventral); 4, the medicerebral (fronto-ventral). Or any two of these trunks may communicate independently, e.g., the ninth and postcerebral veins by a large anastomosis directly across the temporal lobe (oblique), of course. There are some other connecting veins, not so markedly bridging the fissures, however. The great anastomotic vein of Trolard is No. 4 (most commonly) when continuous with No. 2. Labbé's illustration includes also No. 3. Trolard says it "sometimes takes origin at the side of the longitudinal sinus, but almost always by the confluence of other anastomoses at the middle part of the convexity." He encountered it twenty-five times in thirty subjects. According to Labbé this anastomosis, instead of being with the medicerebral vein, is in common with the deeper Sylvian vein. Practically these various anastomoses present a collateral path in the pia between longitudinal, lateral, and cavernous (sphenoidal or superpetrosal) sinuses. The proximal veins, excepting the perforants and the cerebellar, have ample though smaller anastomoses, including an imperfect counterpart of the circle of Willis. It is evident that the derivative area of the pia veins can never be exactly defined.

The internal system must be separated into those veins uniting in the curved portion of the vein and those tributary to the straight portion. The former, as the writer has elsewhere shown, have the following sets of anastomoses: 1, between the callosal vein—including practically the rare interhemispheric vein—and the median branches of the supercerebrals, across the callosal fissure; 2, between the subcerebral vein and the basal branches of the postcerebral; 3, between the supercerebellar and other cerebellar veins; 4, between the subcerebral vein, when, as in about one-half the cases, this discharges into the Galen, and the many veins adjacent to its derivative area. These communications are all in the pia; from clinical cases we know that these may suffice to compensate fairly when only the terminal sinus and the short common vein of Galen are closed. They do not suffice, however, when there is any impediment to this collateral discharge, and possibly not when the subcerebral vein ends elsewhere. Of the veins passing to the portio recta of the vena Galeni, only one, the mesocoelian, has superficial anastomoses. As this is a long, tortuous vessel, and connects with the subcerebral only by small and questionable anastomoses, it is of itself entirely unable to compensate when the portio curvata becomes occluded. We have remaining the various callosal veins coming directly from the brain substance, to which the postcommissural may also be added. Neither between these nor between their subdivisions short of the ultimate capillaries did the writer succeed in finding any anastomoses. The same holds true for the perforating veins of the base. There still might be intra-cerebral connections between these vessels and the cortical venules. However, the apparently positive results of injections by Duret, and especially by Labbé, are all explicable by the surface anastomoses above described. There may be such occasional but inadequate connections paralleled by the rare ones between the otherwise terminal perforating and cortical arterioles. Hédon (1888) says that a few do exist. Clinical evidence also goes to show that the veins emanating from the central walls are all true terminal vessels, and that closure of the great vein—unless just at its mouth—cannot be compensated.

Cortical Venules.—Duret found only six or eight in the section of a medium-sized convolution, one or two emanating perpendicularly at the crown of the gyrus, and from four to six by the sides. However, they have a diameter triple that of the arterioles. They start principally from the capillary transition plexus—between gray and white—and from the deeper strata.

GENERAL RELATIONS OF THE VEINS AND ARTERIES.—In the pia, over the convexity and on the median surface, the arteries lie beneath the veins (dorsad) as generally as the body elsewhere. But over the insula, and evidently in the sulci generally, the writer has observed the reverse, while of the finer pial arterioles Labbé asserts that the venules lie beneath the arterial. Though the larger veins often jump across from one gyrus to the next, the arteries go down with the pia more or less deeply into the fissures, to come up near or distant over the next gyrus.

Only by a forced comparison can any of these veins be said to accompany the arteries. By contrast, the dural vessels conform in most general features to those elsewhere; they have abundant collateral anastomoses, most of the arterial branches are accompanied by two veins, etc.

Dwight quotes the suggestion that, as the blood in the internal jugular and carotid flows in opposite directions, the arterial pulsations might interfere with the venous discharge, if both lay in a common canal. Trolard drew a strong analogy between the vertebral artery, surrounded by the vertebral vein and plexus, and the carotid through the cavernous sinus. "The supply arteries of the encephalon bathe in venous blood; the carotids from the moment they enter the carotid canal; the vertebrals from the moment they penetrate the vertebral canal." This point has recently been elaborated by Rudinger (*vide* abstract in *Boston Medical and Surgical Journal*, 1888, ii., 323). He shows that by this cushioning the pulsatory movements of the arteries are not abolished as they would be if they filled the bony canals. The diameter of the carotid canal he gives as 5–7 mm. ; that of the artery, 3–4.3 mm. In the cavernous sinus the artery, though situated at one side of the cavity, is not in contact with either the bone or the dura.

The various retarding bends and angles in both classes of vessels can only be referred to. They affect very unequally the circulation in the different parts. The existence in the pia of vessels larger than capillaries, connecting the arteries with the veins, has been many times asserted and denied—the last investigator, Labbé, contriving to do both. This point still awaits final settlement.

III. THE DURAL SINUSES.—The encranial sinuses are all intradural, and all except the tentorial (with the falcial) lie against the cranial wall. They do not collapse on being slit open, nor do they admit of much distention—the falcial and the parasinual spaces excepted. They are lined by a continuation of the inner membrane of the jugular. Allen counts 16 sinuses ; 10 paired (symmetrical), and 6 unpaired (azygous). But their number depends so much on the way they are divided as to cause the remark that the easiest piece of anatomical work was to describe a new sinus.

They have been variously classified : (a) In two reciprocally perpendicular planes, the vertical plane including the longitudinal and tentorial (plus falcial), the horizontal including the remaining ; or, (b) in three horizontal planes ; or, (c) as connecting at three points, viz., the torcular and the two cavernous sinuses (to which Trolard sought to add a precondyloid confluens) ; or, (d) according to the area drained.

The Longitudinal Sinus.—This, the longest sinus, runs parallel to the sagittal suture, slightly grooving the bone in a curved line from near the crista galli to the internal occipital protuberance. It lies between the folds of the falx, as they diverge to continue as the parietal dura. Its section presents a rounded triangle, increasing in size from the accession of large veins. Its lumen toward the bottom is crossed by numerous irregular strands (trabeculæ, chordæ Willisii). The openings from the supercerebral veins are usually larger than those from the parasinual spaces (and dural veins). The sini subalterni of Malacarne are often seen in the falx just beneath the sinus, and present more or less developed parallel narrow passages freely connecting with the main vessel. At the torcular this sinus more often turns into the right lateral. Rarely it, or its tributaries, drops down through the falx to the falcial sinus, or just before the torcular to the tentorial, or even divides, following the lambda sutures to each lateral sinus. The whole longitudinal sinus may be occluded without causing disastrous results.

Falcial Sinus.—This may run along about two-thirds of the free border of the falx or near the border, and then represents the continuation of the tentorial sinus. It is rather a large dural vein than a sinus. At its commencement, the occasional interhemispheric veins empty. Its only lateral tributaries are usually small dural veinules, though part of the supercerebral veins or of the longitudinal sinus have in rare instances been seen to turn this way. On the contrary, Knott once saw the falcial pass to the longitudinal, and some connection between the two is not uncommon.

But, as stated by Luschka, this sinus is very variable in size and occurrence. In a series of adult subjects the writer found that its average occurrence was only one in six ; in the fœtus it was never present. Trolard's attempt at presenting this as an important anastomosis between the dorsal and internal systems, or as a safety-diverticle of the latter, was quite overdrawn.

Tentorial Sinus.—This lies at the junction of the falx and tentorium (Figs. 4882 and 4883, *a*). It extends in full size from the torcular to the intersection of the free falcial and tentorial borders opposite the point where it receives its main tributary, the vein of Galen. Its section is a triangle with narrow base resting on the tentorium. Laterally it takes up small dural radicles, and often a supercerebellar vein. It is straight, lies in the median line, and is directed caudad. "It opens into the lateral sinus by an oval mouth formed by strong pillars of fibres."

Torcular.—A *confluens sinuum* in the sense of the old writers does not exist. "The right lateral sinus for the most part begins higher than the left, and may be considered as the continuation of the longitudinal. In some subjects the right or left lateral sinus begins from the longitudinal one, while that of the other side is continuous from the tentorial ; and then the lateral sinuses are separated at their origin by a membranous isthmus" (Charles Bell, 1827). Rüdinger speaks of a "valvular arrangement" separating the two currents. In 26 out of Knott's 44 cases, the tentorial opened into the left lateral sinus, in 6 into the right, in 12 mesially. The statistics given below, on the larger jugular canal, bear on this question. This peculiarity of the paths at the torcular tends to prevent a reflux of blood from one into the other, or any interference of the currents.

However, in a considerable minority of cases the currents must intermingle. From the arrangements of the sinuses at the torcular, thrombosis of the longitudinal and right lateral is more often associated than of the longitudinal and left. A comparison of the few casual cases at hand shows 6 of the former to 2 (or possibly 3) of the latter. Of course, much more frequently—in 12—all three sinuses were involved.

Lateral Sinus.—This runs from the torcular, at first in the attached tentorial border, then curves (*flexura sigmoidea*) to follow the groove in the mastoid and gain the jugular canal. It has been seen to take a more basal course, running first in the cerebellar falx, then beside the foramen magnum to its usual exit. From the extensive investigations of Hartmann, Rüdinger, Bezold, and Politzer, it appears that frequently the sigmoid portion approaches within a few millimetres of the posterior wall of the auditory meatus. The one into which the longitudinal sinus turns, usually the right, is double the size of the other, and also a trifle longer. Rarely, one lateral is minimal in size or even absent. It receives laterally the postcerebral and paracerebellar veins and superpetrosal sinus, and gives off two inconstant emissaries.

Cavernous sinus, distinguished by its irregular outline and cellular or reticulated appearance from intercrossing fibrous bands. It represents a colossal perivascular structure about the carotid, in a way similar to that established by Braune and his school, for certain lymphatics accompanying veins. The late Von Langer, in one of his last publications, based on corrosion and other preparations from infantile subjects, showed that the cavernous sinus is originally a plexiform net-work of veins, which, by fusion of its channels, takes on its later characteristics. The wall-resorption goes on to old age, when villous offshoots of the remaining trabeculæ are often seen to project into its cavity. It is traversed by the carotid (cavernous portion). All the orbital nerves except the optic pass near or through its outer wall. Besides veins and emissaries, it is the communicating centre for all the prebasal sinuses. Frontad it tapers to the ophthalmic vein—the swollen end of which has been dubbed *sinus ophthalmicus.*

Laterally, the cavernous receives the *sphenoidal sinus*. This runs out along the dependent side of the lesser sphenoidal wing. Knott notes great variability in its size, though never complete absence, a small vein at least being found. Peripherally it receives or connects with a medidural vein, and also a diploic canal, and may take up the medicerebral and connect with ophthalmo-dural veins.

The *subsphenoidal sinus*, on the great wing of the bone, was found by Knott 14 times on the right and 9 on the left side.

Mesad, the cavernosi connect by the two *transverse sinuses*—which alone deserve to be called transverse. These follow the walls of the sella turcica, curve slightly to enclose the pituitary body, and complete the so called vene-circle of Ridley.

Sinus præpetrosus (jugularis spurius of Luschka, pe-

(squamo-squamosus of Hyrtl, petrosus anterior of Bell). This occasional sinus, at the bottom of the temporal fossa, describes a curve along the petro-squamous suture, from the spinous foramen—connecting with the meningeal veins and also with the cavernous sinus—to either (or both) the contiguous transverse or the petrous portion of the lateral sinus (often by perforating the prominent petrous ridge). Its physiological interest arises from the prominent part which it plays in the fœtus. Zuckerkandl (1873) found this sinus 22 times in 280 skulls. Knott, [illegible] in [illegible], found what appears to have been a continuation of this sinus to the sphenoidal; in 7 of 44 subjects he found the [illegible] on both sides, in 19 on one side only.

Caudad, the cavernous empties into the oblique superior and inferior petrosal sinuses, but principally the former. The superior petrosal sinus starts from the cavernous, runs in the prolonged attached border of the tentorium along the dorsal ridge of the petrous bone, and enters the lateral sinus against the current at the beginning of its sigmoid flexure. It alone offers a direct intracranial connection between the petrosal and lateral sinuses. The temporal sinus (superior cerebral or anastomotic vein) and the [illegible] vein, the larger (into this in nearly one half the cases, the [illegible] vein more constantly). As a consequence, its size varies considerably, though it is usually small. The vestibular and even tympanic veins of the ear pass to the superior petrosal sinus, either directly or by a dural vein. In his forty-four subjects, Knott notes its absence twice on the right and once on the left.

The inferior petrosal sinus runs in the petro-occipital groove, from the cavernous sinus to the subpetrosal vein, which, by bending before its discharge into the jugular vein, secures an unimpeded outlet for this sinus (for comparison, see Vena Subpetrosa).

Occipito-basilar plexus.—In the occipital fossa are several small sinuses that vary much in size and distribution. The *occipital sinus*, usually bilateral, runs along the cerebellar falx and connects with the lateral sinuses by small mouths beside the torcular. Pre-, trans-, and post-occipitals have been made out. The so-called circular sinus of the foramen magnum is more often incomplete, [illegible] of the hole. The basilar sinuses over the like-named process connect with the preceding and with the petrosal sinuses. Langer has shown that, like the cavernous sinus, all of these are the persistent channels of what originally, in the fœtus, was a vein-plexus; and he has also corroborated Virchow's description of their enlargement in the aged.

Parasinoidal Spaces.—These are the venous pockets or derivative reservoirs (lacunæ, *venous laterales*), though described with increasing definiteness by a long series of observers, find but little mention in the text-books. Their principal development is opposite the middle of the longitudinal sinus (bilateral). As numerous minute spaces they further occur along nearly the whole length of the said sinus, and also (Langer) beneath it in the falx, beside the lateral sinuses, on both sides of the tentorial sinus, and it is said even about the cavernous. The dilated intradural termination of the postcentral and parietal veins has also been thus classed. They all occupy the interstitial space between the dural layers lateral to the sinuses, and hence are very shallow and of irregular outline. They have a lining membrane, also many intersecting fibrous trabeculæ, and are injectable from or with the sinuses. In position and characteristics they are intermediaries between dural veins and sinuses. Where present they receive most, if not all, the dural veins. The larger spaces are traversed by ascending pia-veins, with which they connect by one or more openings. They increase in size as life advances and then have intimate relations with the Pacchionian granulations—so much so that they have even been termed Pacchionian blood-cavities. The circulation in their interior is not believed to be very active, and the spaces have repeatedly been found thrombosed.

On opening a sinus or the mastoid canal, blood usually flows out in a more or less pulsatory stream, showing that the [illegible] interior pressure is positive. In the cases of operative perforation of a lateral sinus (Jacoby, Knapp, [illegible], [illegible], Owen, Reeve, and Von Bergmann), all ending in recovery, there is no record of air being aspirated. But in one case of opening of the longitudinal (Genzmer, 1877) so much air was aspirated as to prove quickly fatal, and François-Franck (1881) has endeavored by experiments to show that aspiration can be communicated through the vertebral veins to the diploic canals of the occiput.

Blocking of any single sinus is not necessarily dangerous, though occlusion of a cavernous or the torcular is always a serious matter.

IV. VENOUS OPENINGS THROUGH THE SKULL (EMISSARIA, ETC.).—From their number and pathological importance, and for clearness of description, these passages ought to constitute a separate class. Each of the cranial bones (unless the ethmoid) has a foramen permitting direct communication between the dural sinuses and veins and the exterior veins; still these are of very unequal size, and in part disappear in the adult. There is not [illegible] topographical correspondence between the position of these exits and the area drained through them, nor is the area in any case closely definable. They may all act as efferent vessels, although the ophthalmic veins are usually afferent—partially so, says Sesemann (1869), largely so, Gurwitsch (1883), and Merkel—and certain of the others may conduct either way according to circumstances. Only Nos. 2, 6, 7, and 8 are superficial, while 7, 8, 11, and perhaps 4 belong rather to the dural and diploic system. Nearly all the blood normally passes out through the two posterolateral foramina with their four canals. But any one of the exits and, so far as known, any two—or, in case of the smaller emissaria, several—may be permanently closed, without causing serious harm. Both internal jugulars have been tied in the same subject (Pilger, 1880) without other evil consequences than a temporary headache.

1. *Jugular Canal.*—In the lateral part of the posterolateral foramen. This, by far the largest of all the exits, leads from the sigmoid flexure of the lateral sinus to the bulb or gulf of the internal jugular vein. Its path through the foramen is often more or less separated from the passing nerves, etc., by a bony septum, thus forming a true jugular foramen. Rarely it is very small on one side, or even absent (4 or 5 known cases).

By adding the series of 159 skulls examined by Dwight to the 100 by Rüdinger, we have 259. In 173 of these the right jugular foramen was larger than the left (i.e., about ⅔), in 65 the reverse (¼), and in 21 the two were equal ($\frac{1}{12}$). This harmonizes with what was said above (see Torcular).

2. *Emissarium mastoideum*, of most importance in fœtal life. It arises directly from the lateral sinus and empties usually into the occipital vein (extracranial), sometimes into the posterior auricular, or even directly into the external jugular. In the 36 perfect skulls examined by Green (*American Journal of Otology*, vol. iii.), it was absent on both sides in 1 and on one side in 1. It was always just behind the posterior limit of the mastoid process. The external opening was opposite the middle (at about the middle of the perpendicular height of the mastoid) in 20, above this in 2, below in 6, and directly on the base of the skull in 1. Its diameter measured 5 mm. in 1, 4 mm. in 4, 3 mm. in 10, 2 mm. in 10, and 0.5 mm. in 4.

3. *Emissarium postcondyloideum* (postjugular vein), passing from the lateral sinus near its termination to the upper cervical or vertebral veins. In 44 skulls, Knott found this on both sides in only 15, on the right in [illegible], and on the left in 10. In Dwight's series of 142 skulls, with unequal jugular foramina, the postcondyloid foramen was larger on the same side as the larger jugular in 34, on the other side in 57, and equal or absent in 52 (the foramen being wholly for the transit of the emissary).

4. *Emissarium precondyloideum*, connecting with the occipital sinus or its basal prolongation, taking up a diploic vein, and passing in part to the subpetrosal vein, in part to the plexus about the vertebral. As pars venosa hypoglossi, Luschka described a cluster of veins

about the hypoglossal bundles as they unite in the inner portion of the foramen, from which two veins passed down the canal. Trolard says that externally the precondyloid foramen presents a deep cavity in which is lodged a true venous confluens. Ventrad its wall is hidden by the external part of the atlo-occipital ligament. He says that this confluens receives five veins: 1, Ventrad and mesad, the medilacerate; 2, latero-ventrad, a connection with the subpetrosal vein; 3, dorsad, a precondyloid vein; 4, latero-dorsad, an inconstant vertebral vein (passing between atlas and occiput, behind the internal jugular, sometimes in a bony canal); 5, a little vein on the pre-atlo-occipital ligament, communicating across with the intraspinal sinuses.

Dwight, in the same series of 142 skulls, found the precondyloid foramen larger on the same side as the jugular in 16, on the other side in 11, the two sides equal in 115. "There does not appear to be any definite relation between their size and that of the postcondyloids."

5. Small uncertain veins through the *foramen magnum* or beside the vertebral arteries, connecting some marginal sinus or vein with the vertebral and spinal vessels. The fine veins in the spinal cord also connect with intrasubstantial ones above.

6. *Emissarium occipitale*, a small mesal conduit from the torcular through the occipital protuberance to the external veins of the occiput. It is often, but not always sinuous, and takes up an azygoid diploic trunk. Knott found it as a small but traceable vein in six of his forty-four cases. In most of the others there was a small vein piercing one of the bone-plates and anastomosing with the diploë veins.

7. *Emissarium Parietale.*—In 100 skulls Gruber found the parietal foramen on both sides in 29, on the right in 19, on the left in 12; average distance from angle of occipital squama, 3–5 ctm.; distance from sagittal suture, 2–17 mm. Their size varies ordinarily from ⅛ to 1 mm. They do not terminate internally directly in the long sinus, but in the parasinual spaces or dural veins.

8. *Diploic Connections.*—Innumerable small openings through the inner plate of the skull connect the dural veins and spaces with the diploë canals. These are largest and most numerous along the longitudinal sinus (corrosion preparation).

9. *Orbital Connections.*—(*a*) The ophthalmic vein is, next to the jugular, the largest and most constant of all the passages. It empties largely into the cavernous sinus (through the orbital fissure, where it bears a constant constriction), but has free anastomosis with the prefacial vein at the inner canthus. Allen says that formerly the trunk of the facial was opened at this point to relieve cerebral congestion. (*b*) The central retinal vein has full anastomoses with the ophthalmic, but goes as a rule to the cavernous sinus, or frequently to a fine venous plexus around the optic nerve, and then by several veinules in part to the subophthalmic vein, in part to the said sinus. (*c*) The smaller subophthalmic vein or veins connect doubly with the larger into which, or oftener into the sinus cavernosus, they discharge (always afferent, say Sesemann and H. Meyer). Peripherally, they anastomose with facial and even pterygoid veins. (*d*) The ophthalmo-dural vein of Hyrtl (1859) is practically included under the more or less constant connection of the medicerebral vein and the sphenoid sinus. Occasionally this sinus or vein has a small anastomosis, through the lateral part of the orbital foramen, with the ophthalmic or other orbital vein. Evidently, the vena aberrans of Verga (1856) should be classed here. As a passage from the ophthalmic vein or cavernous sinus to the lateral sinus, Knott mentions one case (on right); or between ophthalmic vein and superpetrosal sinus, three instances (on left).

10. *The emissary of the foramen rotundum* from the cavernous sinus, and accompanying the superior maxillary nerve as described by Nuhn, was twice seen by Knott (on right).

11. The medidural vein discharges largely through the *oval*, or *spinous*, *foramen.* Nuhn described a pair of veins which, after traversing the oval foramen, formed a plexus about the inferior maxillary nerve and terminated in the infratemporal veins. Knott found these veins on both sides in 18; two veins on right and one on left in 6; the reverse in 4; a single vein on each side in 11; no vein on one side in 5. Luschka and Trolard describe a vein, from the cavernous sinus, that receives dural veins from the anterior petrous surface and departs through the oval foramen; in this case the medidural emerges through the spinous foramen.

12. *Plexus s. Sinus Caroticus.*—Bell (1827) mentions a *vena sodalis arteriæ carotidis*, as an emissary from a petrous sinus, descending through the carotid canal. Rektorzik (1858) seems to have rediscovered this. A prolongation of the cavernous sinus into the carotid canal constitutes the sinus caroticus. This breaks up into a plexus of small veins about the artery, converging to one or more small trunks below, that may pass to the internal jugular. It may connect with 11 and 13. Knott was always able to find this communication, though the vessels varied much in size and number.

13. *Vena Medilacerata.*—Englisch is credited with having described (1863) a constant communication, outside the skull, between the cavernous sinus and the subpetrosal vein. As *inferior petro-occipital sinus*, Trolard independently describes the same. "On the exterior base of the cranium a small vein occupies a groove extending between the two lacerated foramina. Its direction is latero-caudad. It inosculates with cavernous sinus or carotid plexus, and with the precondyloid confluens" (*v. supra, sub* 4). Knott found this in fourteen out of thirty-three cases.

14. *Vena subpetrosa*, from the subpetrosal sinus, through the premedian portion of the foramen postlacerum, to the jugular vein. Here it is separated—not rarely by bony lamina, thus forming the foramen anomalum of Gruber, 1869—by three nerve-trunks from the jugular canal. From numerous investigations Gruber found that only rarely did this vein pass quite through the foramen before entering the jugular, and that then it first connected with the termination of the lateral sinus. However, in 8 out of 22 times Knott found that the vena subpetrosa ended at about the level of the lower margin of the jugular foramen; in 9 a little above; and in 5 a little below. It connects also with the precondyloid vein or confluens, and commonly receives the internal auditory veins.

To these may be added the following, of rare occurrence in the adult:

15. *Emissarium temporale* (foramen jugulare spurium). This is held to be a relic of the primary jugular vein. Where present, it proceeds from the prepetrosal sinus, perforates the temporal bone beneath the root of the zygomatic arch, emerges just behind the glenoid fossa at the edge of the porus acusticus externus, and ends in the external jugular system.

16. *Foramen cæcum*, in fœtal life a communication between the longitudinal sinus and the veins of the frontal sinus, ethmoid bone, and nose. Rarely, if ever, observed in the adult.

17. The very rare, pathological venous blood tumors of the cranium (*v.* Mastin, *Journal of the American Medical Association*, 1886), arterio-venous aneurisms of the scalp, etc., occasionally communicate on the one hand with external veins of the head, on the other through openings in the bone usually with the long sinus.

LYMPHATIC SYSTEM IN THE BRAIN.—There are no lymphatic glands in the cranial cavity; nor does the brain possess a system of independent lymphatics. Within the brain-substance all the larger lymph-passages accompany the blood-vessels as cylindrical enveloping spaces. These are at least twofold: (*a*) *Adventitial* spaces between media and adventitia, which latter are not closely bound together in the vessels of the central nervous system as in the remainder of the body; (*b*) *perivascular* spaces of His and Robin, connecting with the subpial or so-called epicerebral space. Their existence in normal tissues has been repeatedly disputed, and unquestionably their size is artificially much increased by the usual methods of preparation. The latest investigators, Rossbach and Sehrwald, assert very positively the tral extension of these spaces. They verified by Golgi's method, claiming that this traces the lymph, and thus the lymph-spaces rather than the ganglion-cell and its processes.

The beginning of the lymph passages is to be sought in the very narrow spaces surrounding the ganglion-cells—pericellular spaces (Obersteiner). In each of these latter spaces end, according to Rossbach and Sehrwald, many fine canaliculi, often running a long distance through the tissue, and starting [illegible] from cells lymph-spaces. These surround the protoplasmic cell processes. The efferents from these cell-spaces pass along the axis process, inward, and empty into perivascular and superficial glial spaces, or directly into the epicerebral space. The lymph-system of each ganglion-cell has no direct anastomoses with that about any other such cell. They also describe a lymphatic plexus about the glia cells (perivital spaces), especially in the external cortical layer and in the first subcortical [illegible]. These are often intermediary between the pericellular spaces and the perivascular spaces, into which latter and the epicerebral space they empty.

The lymphatics of the choroid plexus in the paracele course (Arnold) to one trunk following Galen's vein. In the parenchyma lymphatic net-works have occasionally been observed.

The lymph passages collect in the pia to larger trunks, follow the course of the veins, and pass out, in part through the jugular foramen to superjugular glands, in part through the carotid canal to the deep cervical glands, in part beside the vertebral vessels to the infrajugular glands.

SEROUS CAVITIES, CEREBRO-SPINAL FLUID, ETC.—Between dura and arachnoid is the *subdural space*. In the normal condition this contains only a capillary layer of fluid. The dura has a system of lymphatics accompanying the blood-capillaries within their adventitia. Besides, in the endothelium of the dura independent lymphatic plexi and stomata have been described, presenting a communication with the subdural space, and conducting off the subdural fluid. Through the oval and spinous foramina pass (Arnold) lymphatics to the deep facial glands, probably coming from the dura.

The interspaces of the pia, i.e., the somewhat broken room between arachnoid and pia proper, constitute the subarachnoidal space (*cavum subarachnoideale*). This is the reservoir of the cerebro-spinal (cephalo-rachidian) fluid. Although this fluid can pass back and forth between the supratentorial cephalic and spinal spaces, it is no longer held that there is a continuous ebb and flow from one to the other at each respiratory movement and every pulsation. This space is exceedingly attenuated wherever the brain lies close to the skull, as over the convexity. At other points it forms lacuna-like pockets, termed by Key and Retzius cisternæ. Among these may be mentioned: *Cisterna magna cerebello-medullaris*, where the arachnoid spreads across from the caudad border of the cerebellum to the oblongata; *cisterna fossæ lateralis* (*cisterna Sylvii*); and over the optic lobes the *cisterna ambiens*. The cavæ connect with these cavities (the cerebral fluid comes from the choroid plexuses), the metacele with the cisterna magna through the foramen Magendie and the aperturæ laterales; the paracele with the cisterna of the base, by the lower horn, over the great hippocampus. There is no canalis Bichati, formerly supposed to connect the paracele with the subdural space. Hence, while the cœlian and subarachnoidal cavities are united, neither has any direct connection with the subdural space. An indirect connection may be effected by the nasal lymph-net, as this may be injected from the subdural as well as subarachnoidal space by way of perineural lymph-passages about olfactory nerves. Another assumed indirect connection is by the Pacchionian bodies and the sinuses. The experiments of Key and Retzius, confirmed by Kollmann (1880), seem to show that the perforations of the dura—opposite venous sinuses—by these bodies furnish one of the principal drainage paths for both subarachnoidal and subdural spaces. Probably, however, their injections produced artificial openings not existing intra vitam. Certainly they do not usually attain any development until long after youth has passed. Further reasons in opposition are given by Adamkiewicz in his polemic ("Eulenburg's Real-Encyclopädie," 1886, Art. Gehirndruck) against Bergmann's theory of brain-compression, and in favor of his own somewhat novel views. Material injected into the subarachnoidal space in animals traverses the superior cervical and submaxillary glands. In man it can pass out in the optic sheath to the bulb, in the sheath of the facial and the acoustic as far as the internal auditory meatus—whence fracture of the petrous with tearing of the nerve sheath leads to escaping out of cerebro-spinal fluid—and finally to the lymph-tubes in the nasal mucous membrane, the supposed path of meningeal infection from nasal sources.

The subarachnoidal cisternæ protect the large basal vessels from compression, and in like manner the pericellular spaces shield the ganglion-cell and its process from shock and pressure. Further, the perivascular cisterns protect the brain-substance (His) in a more general way.

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CEPHALOCELE (encephalocele, hydrencephalocele, hydrencephalocele, cephalhydrocele, meningocele, hydromeningocele, craniocele, hernia seu fungus seu ectopia cerebri).* Hernia of the brain or meninges is a name given to a protrusion of a portion of the contents of the cranial cavity through an opening in the skull beneath the scalp. There is need of greater simplicity in what is now a rather confusing terminology, and it would seem that the best designation for all of these tumors as a class is cephalocele. There is a correspondence in application between this word and enterocele, because of the similarity of their constituents. There is a hernial canal or opening in the skull, a hernial sac consisting of the dura mater, the hernial contents composed of whatever substance or fluid may be forced out from the cranial cavity, and, finally, the various coverings of the hernia, such as the pericranium, fascia, and skin. It is necessary, in a true cephalocele, that the dura mater form the hernial sac. The tumors formed beneath the scalp in traumatic lesions of the skull and dura, by the pouring out of cerebro-spinal fluid, are not true cephaloceles, and are more properly termed *pseudo-meningoceles.* Protrusion of brain-substance in compound fractures of the skull is not considered here, though sometimes improperly called a hernia cerebri; the correct designation is *prolapsus cerebri.*

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* See Editor's Note at end of article.

The varieties of cephalocele depend upon the contents of the tumor. Hence we have a *meningocele* where the hernial contents are cerebro-spinal fluid alone pressing out the dura mater; a *hydrocephalocele,* where the tumor consists of an internal hydrocephalus expanding and forcing outward the ventricular walls; and, finally, an *encephalocele,* composed wholly of brain-substance with more or less fluid usually surrounding it.

These tumors are mostly of congenital origin, but there are certain rare cases in which they are acquired after birth, through disease of the cranial bones or traumatism. It is usual, therefore, to distinguish two forms of cephalocele, the congenital and acquired. In describing the latter it will be best to use the prefix *pseudo.*

Congenital Cephalocele.—These tumors almost always have their pedicles at or in the immediate neighborhood of some cranial suture. The great majority are in the antero-posterior median line, as a rule either in the frontal or occipital region. According to Giovanni Reale, who collected 68 cases of cephalocele, 10 were at the nasal root, 9 in the frontal suture, 5 at the posterior fontanelle, and 22 in the occipital bone, the rest arising from some of the lateral sutures. Larger tabulated 85 cases, 44 of which were occipital, and 41 frontal or sincipital. The favorite location of the sincipital tumors is at the root of the nose, either at the inferior part of the frontal suture or at the junction of the ethmoid and frontal bones. The hernial canal or opening is generally bounded by the separated or more or less malformed ethmoid, frontal, nasal, or lachrymal bones, and sometimes even the nasal process of the superior maxilla. The occipital cephaloceles are the most frequent of all. They are situated either in or near the posterior fontanelle, or lower down under the occipital protuberance, where the hernial opening may be conjoined with the foramen magnum. Hernial protrusions from other sutures are much more rare, although they do occur in the greater fontanelle, in the squamous suture, or between the ethmoid and sphenoid bones at the base of the skull.

Cephalocele is uncommon, Trélat finding but 3 in 12,000 births, and Vines 1 in 5,000. It is said to be more common in females than in males, though Z. Lawrence (quoted by Erichsen, "Surgery," vol. ii., page 378) collected 39 cases, 21 of which were males.

The tumors vary in size from that of a pea to that of a child's head. The occipital are always the largest, and are usually hydrocephaloceles. The sincipital tumors are, as a rule, small and simple encephaloceles. Meningoceles may exist in either place, but are more common behind. Hydrocephaloceles are rarely sincipital, owing to the positions and conformations of the ventricles, which are more apt to dilate posteriorly.

The occipital *hydrocephaloceles* are usually constricted at their base, often pedunculated, almost globular in form, and seldom attached by broad bases. They generally contain the dropsical posterior horns of the lateral ventricles or their fœtal analogues. Those in the lower occipital region enclose the cerebellum and the hydropic fourth ventricle. In some of the largest hydrocephaloceles have been found a great part of the cerebrum, the cerebellum, fourth ventricle, and quadrigeminal bodies. The protruding cephalic parts are commonly of inferior or defective development, often difficult to recognize as brain-substance, owing to cystoid degeneration and sclerosis (Huebner). Sometimes the constriction at the hernial opening is so great that there is marked stasis of blood in the pia, which may lead even to extravasations. Occasionally these tumors present longitudinal constrictions caused by the venous plexus or by the falces of the dura. The quantity of fluid contents varies, but may reach two quarts. It has been found to be rich in albumen, with a specific gravity of 1.010–1.012.

The *meningoceles* of the occipital region are quite as large as the hydrocephaloceles, and similar in shape, while those of the sincipital and lateral areas of the skull are much smaller. One very large meningocele held fluid which had a specific gravity of 1.004, and contained a small quantity of albumen, uric acid, chloride of sodium, and biliary coloring matters (Heineke).

The *encephaloceles* are usually small tumors with broad bases, having a diameter as a rule between one and three centimetres, generally occupying a position at the root of the nose, and containing often, besides cerebral substance, a small quantity of subdural fluid.

Pathology.—There are several theories advanced to account for the origin of these congenital tumors. One is, that there is a limited ventricular dropsy, which by pressure at some certain circumscribed portion of the skull expands and separates the cranial bones and thus protrudes. From a hydrocephalocele thus formed an encephalocele may be produced later, by reabsorption of the dropsical fluid; or a meningocele, by a recession of the cerebral substance into the cranial cavity. The arguments against this hypothesis are, that there would scarcely be a circumscription of the dropsy as imagined, but rather a tendency to a general hydrocephalus; and, furthermore, Ackermann and Heineke have determined that there is a diminution, and not an increase, of intracranial pressure in cases of cephalocele.

A more probable theory as to the etiology of these tumors is, that they originate in the early embryological periods, when the cerebral vesicle and its fluid contents are in process of growth, and their osseous capsule is not yet developed. There is then an arrested or defective evolution of the cranial vault, as a result of which complete closure of the skull does not take place, and a circumscribed portion of the fœtal brain-vesicle protrudes. According to this hypothesis, hydrocephalocele would belong to an earlier stage of development, and encephalocele to a later, when the protruding portion of brain no longer exhibits the configuration of the fœtal brain-vesicle as it does in the former. In like manner, meningocele may originate either by the mere extrusion of the dura mater through pressure of the subdural fluid, or by the bursting of a hydrocephalocele, or it may be the remnant of a disorganized encephalocele. Meningocele might also spring from the cerebral vesicle in the earliest stages of development, as a mere membranous cyst without brain-substance. Yet, if the defect in the skull were the only factor in the formation of these tumors, it would be difficult to understand why they are not present in every child in the open cranial spaces, the fontanelles. We are compelled, therefore, to recognize, as another factor in their causation, a general or partial hydrocephalus, either internal or external.

This conception of the embryological origin of cephaloceles is corroborated by the fact that most of them are found in front and behind the head, in the median line, which is the most marked direction of growth of the cerebral vesicle; and that other defects and malformations of the skull, face, spine, feet, etc., are often observed in connection with these cases. Thus striking departures from the normal shape of the skull are particularly noticeable in hydrocephalocele and the large meningoceles, where there is often asymmetry, thickening of the sutures, microcephalus, flattening from before backward, and sometimes hydrocephalus; while in the simpler tumors the skull presents, as a rule, a wholly normal configuration.

What may be the ultimate causes of these defects can only be surmised. Premature union of the meninges with the amnion, and injuries to the fœtal head *in utero,* may sometimes be the occasion of their development.

Clinical Features.—The cutaneous surfaces of the cephaloceles are usually smooth, more or less distended, and sometimes very vascular. Occasionally they are excoriated, or present old cicatrices. Angiomata and lipomata have been described as forming upon cephaloceles (Larger, Ried). Hydrocephalocele and meningocele exhibit a distinct sensation of fluctuation, while the encephaloceles have more of a sensation of softness and elasticity, but also show fluctuation if surrounded by a sufficient quantity of fluid. When the coverings are thin, from great tension by fluid contents, these tumors may be translucent. They frequently pulsate synchronously with the pulse and respiratory movements, and their tension is often variable, as there may be a sinking of the tumor in sleep and marked bulging out in the acts of crying or coughing. They may sometimes be diminished in size by pressure, which if moderate does no harm, but if great not infrequently produces symptoms of brain-compression, such as vomiting, retardation of the pulse, unconsciousness, and convulsions. Pulsation is, as a rule, absent in meningocele and hydrencephalocele, but this naturally depends directly upon the size of the cranial opening in the skull and the intercommunicability of the contents of the sac with those of the cranium; these tumors also show generally little variation during sleep, coughing, crying, or upon the application of pressure, unless the cranial foramen is large. Symptoms depend to a great extent, too, upon the physiological value of parts protruded; and in encephalocele such parts are often very different from their analogues in the normally developed brain. In the light of the recent discoveries in cerebral localization these cases might often afford very interesting results by careful study.

Prognosis.—Many children affected with meningocele or hydrencephalocele die before or during birth. Sometimes the tumor bursts during parturition. Those born living rarely last many years, partly on account of the imperfect condition of their brains and partly because the tumor often rapidly increases to such size by the superaddition of cerebro-spinal fluid that it bursts spontaneously, causing death either speedily, in coma or convulsions, or slowly, from a consecutive meningitis. Recovery after such evacuation of the tumor takes place but rarely. Death occurs usually in the first two or three years of life, but a few children with meningocele have attained the age of twelve, and even seventeen years.

The encephaloceles being smaller and simpler than the varieties just mentioned, still-birth and rupture are less common in cases affected with them, although they do occur. As a rule, this class either grows slowly or remains stationary. Whatever disturbance is excited is due to disorder of brain-function, but patients suffering from the frontal variety live longer and with fewer cerebral symptoms than those afflicted with the occipital variety. Children with occipital encephaloceles are generally idiots, whereas with the frontal or sincipital tumors they are more commonly of quite normal intelligence. Many have reached adult age.

Spontaneous recovery from encephalocele and meningocele has occurred, according to the observations of Wernher, Textor, v. Bruns, and Held, by closure of the cranial defect and the complete isolation of the tumor as a cyst on the outside of the skull. Operative procedures have proved successful in some instances.

Diagnosis.—Every tumor of congenital origin situated along the median line of the head, in the region of the root of the nose or in the glabellar or occipital regions, should excite suspicion of a cephalocele; and defects or malformations in other parts of the skull or body would be corroborative evidence. The fact of its being congenital must first of all be determined; then its relation to the various cranial sutures. The diagnosis is easy when the tumor is in one of the situations that have been described, when there is pulsation, a sensation of fluctuation, when there is a change in tension during sleep or in crying, and when there is a reduction of its contents into the skull upon pressure. If, at the same time with the reduction of the brain-substance or cerebro-spinal fluid, symptoms of irritation or compression of the brain develop, if there is an increase in the pulsatory or respiratory brain-movements, and particularly if the edges of the bony opening in the skull can be felt, a cephalocele is certainly present. But sometimes most of these pathognomonic symptoms are absent, and the diagnosis can be made only from the seat and history of the tumor. Although seldom necessary, a fine aseptic hypodermic needle may be introduced to determine the character of the contents and the presence or absence of an opening in the skull.

The recognition of these hernias in the occipital region is easiest, because other congenital tumors of similar form are of extreme rarity in this position; but dermoids, angiomata, and sarcomata of prenatal origin may have their seat at the nasal root, in the frontal region, or at the inner canthus of the eye, and thus lead to confusion. In the case of these latter the mode of development must be carefully studied, and note taken of variations in tension, compressibility, pulsation, and of the appearance of cerebral symptoms upon pressure. Angiomata exhibit pulsation and tension changes, and may be often completely compressed, but without brain-symptoms or the discovery of an opening in the skull. Pulsation and compressibility are lacking in dermoid tumors. Cranial sarcomata, which are congenital or which appear shortly after birth, may present brain-symptoms on pressure, and an opening in the skull, may pulsate, and may have a similarity of feel, but they grow much more rapidly than cephaloceles and usually are wanting in the more characteristic symptoms of the latter. The differentiation of the varieties of cephaloceles can be made from the peculiarities that have already been described.

Treatment.—The most difficult class to treat are the hydrencephaloceles, but measures can at least be taken to prevent sudden death by spontaneous rupture of the sac. This is still more important in meningocele and encephalocele if there be a rapid increase of fluid and tension, as a cure is possible in many of these cases. Equable pressure should be made by means of cotton batting and a bandage, care being taken not to produce brain-symptoms by too strong compression. If the distention increases puncture should be made with a hypodermic needle, with antiseptic precautions, and the fluid slowly aspirated—all of it if the tumor be small, but only a portion in large sacs. Then cover with aseptic cotton and continue the compression. Puncture may be repeated at appropriate intervals. If rupture has already taken place, the antiseptic dressing and pressure bandage should nevertheless be applied. By this procedure rupture may be prevented, the tumor may be gradually diminished in size, and occasionally even dissipated. Youths or adults who are occasionally observed with stable encephaloceles should wear protective plates properly curved, with bandages, and sometimes compression may be made use of, if it be deemed expedient to do anything, but great care is needed to avoid the production of brain-symptoms. Puncture in simple encephaloceles is only permissible in case of continual augmentation in size—no other operative procedure is advisable. This is about all that can be done without risk. In many cases where incisions have been made into these tumors through a mistaken diagnosis, the result has been death from meningitis. Puncture and the injection of iodine have been fatal.

Meningoceles are more amenable to treatment, as a rule, than the other forms of cephalocele. Occasional puncture, together with compression, have met frequently with good results. Little is to be expected from iodine injection, although Paget was successful with it in one instance. The stable meningoceles should, as a rule, be let alone, because they communicate almost always with the cranial cavity. Annandale in one case ligated the peduncle and removed the tumor, the child recovering completely in spite of an attack of measles. Thompson has also cured a case by ligation. Schatz cured a case by the gradual compression of a clamp applied to the sac. Sklifasowsky removed an occipital cephalocele from a nine months' child with a ligature, the result being successful. The procedure is permissible in proper cases, under strictly antiseptic precautions. No operations in these cases have been undertaken since the inauguration of the new era of brain-surgery, but doubtless much can now be achieved in the treatment of congenital cephaloceles guided by the light of the latest discoveries in cerebral localization and by the improved technique in cranio-cerebral operations, which was formerly impossible.

ACQUIRED, OR PSEUDOCEPHALOCELE.—Among the cephaloceles which originate subsequently to birth, through disease of the cranial bones or subcutaneous fractures, the most common is the pseudo-meningocele. This is observed almost exclusively in infancy or early youth, but, in very rare cases, sometimes in adults after healing of the superficial skull-coverings in fractures. Conner has written the best article upon pseudo-meningocele that is to be found in American literature. Under the name traumatic cephalhydrocele he describes two cases occurring in his own practice, and makes an analysis of 22 others collected from general literature ; 19 of these were due to subcutaneous fractures of the skull, 2 to old gunshot wounds of the skull and membranes where the scalp had reunited, and 1 was the result of trephining ; 17 of the cases were under three years of age. G. Vivien has collected 8 cases, and Thomas Smith ("St. Barth. Hospital Reports," vol. xx.) reported 2, and described 20 analogous cases. All of Smith's were under sixteen years of age.

The history is usually that a child falls upon its head, and that, several hours or days after, a fluctuating swelling develops under the scalp, which may at first be diffuse, but later, as a rule, assumes the form of a sharply bounded cystic tumor. It may reach the size of the fist or be larger. It is over the injured spot, fluctuates, and often pulsates. There is sometimes a hardened border to the tumor. Occasionally, by firm pressure, the fluid may be made to recede more or less completely into the skull-cavity, when the fractured bone may be felt. Where this is not possible, the break may often be felt after puncture and evacuation of the tumor. In many of these cases puncture has shown the contents to be cerebro-spinal fluid. In post-mortem examinations which have been made, the fluid has been found to lie under the pericranium, lifting it with its outer coverings like a cystic sac ; a cleft is observed in the bone, and one of the same size or smaller in the dura matter, through which the sac and subdural cavity communicate. Occasionally the cortex has been injured, and in recent cases there would be signs of softening and of laceration of the other membranes. In a case of Lucas, the pseudo-meningocele communicated with the open inferior horn of the left ventricle. Two or three cases may be mentioned in illustration of this traumatic form. Southam (*British Medical Journal*, May 12, 1888) gives the details in the case of a male infant, aged six months, that fell down-stairs and sustained a subcutaneous fracture in the right parieto-occipital region. Fourteen days later there was a swelling over the fracture, oval, soft, fluctuating, and pulsating. Moderate pressure was applied with a pad of lint and a bandage. In a month the swelling had disappeared and the child recovered. There was still a marked depression in the bone. Conner's first case was a boy twelve and a half years of age, who fell from a wagon, a wheel passing over his head. He was not unconscious, and walked into a house near by. There was a simple depressed fracture of the right half of the occipital bone, and a non-pulsating swelling over the fractured area, which he supposed due to extravasated blood. A week later serum began to ooze from the nose, and there was puffiness of the right eyebrow. He punctured and drew off four ounces of a pale straw-colored fluid. The sac rapidly refilled, and four weeks later five ounces were removed. There were four subsequent tappings, the fluid withdrawn aggregating nineteen ounces. The specific gravity was 1.007 ; no albumen ; sodium chloride, 6.6 parts per 1,000. The boy was never unconscious or delirious, but there was some insomnia and mental irritability, and the pulse ranged from 100 to 120. Conner's second case was a hydrocephalic and rachitic colored child about two years of age, that fell a distance of five feet upon its head. There was no scalp-wound, but a swelling appeared very quickly over the right parietal bone. In a few days it measured four and a half by three and a half inches, and exhibited pulsation and fluctuation. A radiating fracture could be felt through the tumor. No treatment was undertaken, and nine months after the accident the swelling had disappeared.

There are several facts which explain the almost exclusive prevalence of traumatic pseudo-meningocele in children. Possibly the flexibility of the skull gives a peculiar character to the fracture. The intracranial pressure is certainly relatively greater in children than in adults, and a more active secretion of cerebro-spinal fluid is probably another factor. The increase in subdural fluid may be due in part to the injury to the head, or in part to nutritive disturbance, rachitis, or some such thing, which does not give rise necessarily to a general hydrocephalus. The pouring out of the fluid, its augmented secretion, and the expansive power of the growing brain, all aid in preventing closure of the osseous fissure, and, indeed, may actually cause its enlargement, and even eversion of its edges. But pseudo-meningocele is not a constant result of subcutaneous fracture in childhood, and it is likely that various causes and conditions conduce to its formation.

There are not many observations as to the further course of traumatic pseudo-meningocele in children. Conner found that fifty per cent. of the cases collected by him died of meningo-encephalitis. In some patients the tumor remains unchanged in spite of frequent puncture, and in others it is cured by this means. Spontaneous retrogression may take place. The cleft in the skull generally remains open, and hence the prognosis is always relatively unfavorable. These cases are often of considerable forensic interest.

Pseudo-meningocele in adults has been observed several times after gunshot wounds of the skull, when the scalp-wound has healed, and once after recovery with defect of bone from trephining. Vivien mentions three such cases. As a result of subcutaneous fracture in adults it has apparently not been observed, and, if it occurs, must be extraordinarily rare.

Pseudo-cephalocele sometimes results from syphilitic or tubercular caries of the skull and perforation of the dura mater, and from complicated fractures accompanied with prolapsus cerebri. Such cases have been reported by Benett, Tavignot, Bryk, Podrazki, Spring, Hawkins, Talko, Bruns, and Kusmin. In one case only did the dura mater protrude.

These tumors vary from two to five inches in diameter, and are usually of a soft, elastic consistence. The skin over them is either smooth, glossy, and pale red, or inflamed, indurated, and presenting fistulous openings. Sometimes there is pulsation and fluctuation. Dizziness, retardation of the pulse, and even unconsciousness can, as a rule, be produced by pressure upon them with the finger. Partial replacement may be brought about by compression, and in one case there was complete return of the hernia by gradual pressure. Where the brain has protruded, it was doubtless due in many cases to the formation of cerebral abscess or to collections of pus in the cavity of the skull ; in some cases, probably to œdema or encephalitis with tumefaction of the brain in the neighborhood of the diseased or injured skull.

Treatment.—In pseudo-meningocele continuous and equable pressure should be employed where practicable. If the tumor is large and tends to increase in size, operative interference is allowable, but this should be restricted to the removal of a limited amount of the fluid by aspiration, and is only justifiable when severe pressure symptoms supervene. Strict antiseptic precautions should be observed, and a compress subsequently applied. Irritative injections are not advisable. If the opening in the skull remains patent it is well to keep it shielded by a bandage for the prevention of a renewal of the tumor or injury to the brain. Tonics, nutritious diet, and lime preparations are indicated.

Other forms of pseudo-cephalocele are treated according to the nature of the bone disease or injury. In suppurative processes we must be on the lookout for pus-deposits in the brain or skull cavity, and remove them if feasible, with careful asepsis. It is best not to operate on the prolapsed brain itself, but in this we must be governed by what we have recently learned with regard to the physiological value of different convolutions. Hitherto such heroic measures have been carried out usually as a result of error in diagnosis, and in these cases death has followed from meningitis, encephalitis, or hæmorrhage.

Compression should be naturally resorted to in these cases only where there are no symptoms of inflammation or suppuration. In the rare [illegible] of adults we may cautiously puncture and make use of the [illegible], but should always be on the lookout for symptoms of inflammation and abscess.

[illegible]

[illegible]

Frederic Peterson.

[illegible]

CEREBRO - SPINAL INJURIES (MEDICO-LEGAL).

So long as human nature remains what it is, expert evidence will be open to suspicion. It is possible, of course, even for a man who is paid for testifying on one side of a case in court to keep his mind absolutely free from bias, but to do so he must have qualities of a high order. An uncommon degree of honesty is essential, but it is not sufficient; there are needed besides a certain judicial temperament and some power of introspection. When, however, an expert possesses these qualities and has acquired the reputation which they naturally bring, his authority with the court is very great; and of this there have been conspicuous instances in patent litigation, where civil engineers, chemists, and others are called upon to discuss intricate pieces of mechanism and compositions of matter. In questions relating to medicine and surgery the testimony of the expert is even more important, because, as a rule, the premises upon which he reasons, as well as the conclusions that he draws from them, are supplied by himself. That is, neither his diagnosis nor his prognosis can be verified by a judge or jury; they must trust to him both as to the nature of the disease from which the patient is suffering and as to its probable course and duration. When the medical experts in a particular case disagree, there are two means of deciding between them. In the first place, it is of course open to the jury to weigh, according to such power or sufficiency of judgment as Providence may have bestowed upon them, the rival assertions and arguments that are advanced on each side; and, secondly, there is what may be called the medical presumption that arises in the whole class of cases to which this particular suit belongs. A very slight investigation is sufficient to show that, in cases of railway spine and of nervous shock, the medical presumption has played a more important part in courts of law than all the other evidence put together. In 1866 Mr. Erichsen's famous work on concussion of the spine was published, and in the two years that followed, according to good authority, seven millions of dollars were paid by English railway companies to real or pretended sufferers from accidents on their lines. There is perhaps nothing in the history of the medical profession which illustrates more clearly the powerful influence that can be exerted by a single eminent authority. Erichsen's statements were received almost without question by the great body of medical men who were contemporary with him, and his book proved, as one writer says, "a godsend to plaintiffs and prosecuting attorneys." The Medical Presumption established by Erichsen was, roughly speaking, that severe, long-continued, and in some cases fatal, disease of the spinal cord and its membranes is likely to follow such injury to the back, or even such a jar, as is often received in railway accidents. He defined the celebrated phrase, "concussion of the spine," as being "generally adopted by surgeons to indicate a certain state of the spinal cord occasioned by external violence; a state that is independent of, and not necessarily, uncomplicated by any obvious lesion of the vertebral column, such as its fracture or dislocation; a condition that is supposed to depend upon a shake or jar received by the cord, in consequence of which its intimate organic structure may be more or less deranged, and by which its functions are certainly greatly disturbed, so that various symptoms suggestive of loss or modification of innervation are immediately or remotely induced." A second, revised and much enlarged, edition of his book appeared in 1875.

The symptoms indicative of the disease described by this author becoming well known, and being easily simulated, were, and in a lesser degree still are, made the basis of many fraudulent claims against railroad companies. Mr. Erichsen himself was not unaware of this result, for in the second edition of his work he said: "An extensive experience in railway compensation cases will probably impress you more with the ingenuity than with the honesty of mankind. A history of deceptions practised upon railway companies by alleged sufferers from accidents upon their lines would form a dark spot on the morality of the present generation." A later writer states, with what would seem exaggeration, did not the facts bear him out, that "great moral courage is required to resist the temptation to magnify injuries for which pecuniary compensation may be had"; and he continues: "Too often have railway accidents had a baneful influence on the lives of men, whose greatest calamity it has been, not that they have received physical injuries which have maimed their bodies, but that their moral natures have been seared and twisted by abandonment to this temptation, the escape from which they would not see. It is not the language of sentiment, but of sober fact, when we say that whole households are sometimes made miserable by the devices to which it is needful to resort in order to gain the desired end. . . . So powerful indeed is the motive, that we find persons taking for long to their beds, abstaining from food, shutting themselves up, neglecting their business, and making themselves weak in body and wretched in mind."

Page relates the following typical case ("Injuries of the Spine and Spinal Cord," second edition, p. 272): "T. J., forty-three years of age, was in a slight accident in which he had a small bruise on one cheek and also at the back of the head. He was seen shortly after the accident, but there was no sign, either of injury, beyond the bruises named, or of constitutional disturbance. In about ten days he was 'taken worse,' but in no very definite way. He gave notice of a claim, and then began to complain indefinitely of a pain in the back, of pain in the legs, and oppression in the head. There was still, however, no evidence of illness or constitutional disturbance. He continued to get worse, and two months after the accident took to bed. He had not been in bed many days when he had a 'bilious attack' with constipation and vomiting. This pulled him down, and he made no further attempt to get up. A month elapsed, and he then was seized, so he said, with a convulsive attack in which his legs were drawn up, and he was very violent. From that time forward he professed to be troubled with 'contractions of the limbs and severe pains in the legs, aggravated by attempting to sit up.' He also complained of queer sensations all over, numbness of the tongue, for example, creeping in his legs, tenderness of the palms of the hand. Pulse and temperature alike remained perfectly normal. Five months after the accident he was still in bed, complaining of great pain in the back, of pain and tenderness in the legs, and of inability to stand if he got out of bed. He held his hands out somewhat in the position of tetany, but the contractions immediately disappeared when he ceased to direct attention to it. Although, when he first got out of bed he allowed his legs to slip away and himself to fall, he had only to be engaged in conversation to show that his legs were amply strong enough to support his whole body. There were no objective signs whatever of paralysis, nor was any illness to be discovered about him except such as might fairly be accounted for by his having been in bed for three months. Thus his muscles were somewhat flabby, his face was pale, and his tongue was furred. Temperature and pulse, however, were normal; his pupils were of healthy size; his mind was perfectly clear. So his state continued until the close of a year, when his claim was settled by compromise on the verge of litigation. We say 'on the verge of litigation,' for it was held that this man had received a very severe injury to his nervous system, that prospect of recovery was very small, and that it was wholly impossible for him to appear and give evidence as plaintiff at the action. His evidence was indeed taken by commission, the man being quite unfit to leave his bed. . . . Mark the sequel! In ten days this man was out of doors, in a fortnight he went away for change of air, and in two months he resumed his usual work. He has continued to work since that time in the enjoyment of good health."

The writer just mentioned, the first edition of whose work appeared in 1882, and many others whose observations were published about the same time or a little later, have overthrown the Medical Presumption, as I have called it, established by Mr. Erichsen. These authors, having carefully examined the evidence furnished by actual cases, show pretty clearly that "concussion of the spine," in the sense in which it was used by Mr. Erichsen, is, instead of being a common, a very rare condition; and that many of the symptoms supposed to be indicative of this condition are really signs of functional disorder, hysterical or otherwise, and in numerous cases absolutely feigned. The disrepute thus cast upon "concussion of the spine," or "railway spine," as it is called, as the effect of collisions and other accidents, has doubtless resulted in much injustice to plaintiffs; just as Mr. Erichsen's theory, which went to the opposite extreme, undoubtedly occasioned what was nothing less than robbery of defendant corporations. In fact, a new Medical Presumption was set up, as unjust as that which it succeeded; and inasmuch as both views, the Erichsen and the anti-Erichsen, have their money-getting or money-saving value in courts of law, they are still made the basis of medical opinions expressed in the witness-box. "There are some members of our profession," said a London doctor, "who have become specialists in this direction, who seem to think that everything that a man tells them of his subjective symptoms are matters of fact and of great importance; and, on the other hand, there are those who regard every plaintiff as either a knave or a fool, and most probably a combination of the two, but who never believe that any man is injured in a railway accident unless he has broken his neck, or has a compound fracture of his thigh." [1]

The present state of medical opinion upon this subject is much more reasonable than it was in Erichsen's time, or in the brief period of reaction which followed. There are still to be found, as has been said, witnesses who take one or the other of the extreme views so graphically indicated in the passage just quoted; but the profession, as a whole, has repudiated them both. In the minds of disinterested and instructed physicians there no longer exists what I have termed a Medical Presumption upon the point, and courts of law are quick to reflect the change. Each case must be judged by itself: the evils that Erichsen described might result from a railroad accident, although there is no probability that they will occur. On the other hand, the patient may be suffering only from slight and insignificant strain or bruise, the effects of which will disappear so soon as his damages are settled; but, again, the gravest psychical disorder, or hysterical condition, or neurasthenic state may have been incurred and may be lasting, although no indication whatever be discovered of structural or organic disease. As to the main injury discussed by Erichsen, namely, concussion of the spinal cord without perceptible lesion of its bony covering, the evidence in regard to it would make its existence appear probable, though perhaps not certain, to a court of law. This seems to be the conclusion of the latest and most thorough investigators. One point bearing on this question may be noticed: Page, in the work from which I have quoted already, says: "Simple concussion of the brain may give rise to a transient unconsciousness, and, if the analogy holds good, concussion of the spine should *per se* produce a transient paraplegia. We know of no case, nor can we discover the history of any case, where this has happened." On the other hand, in Pepper's "System of Surgery," where the above passage is quoted, two examples are given of transient paraplegia due to spinal shock or concussion.

Another consideration which has been much dwelt upon is thus stated by Page: "How comes it that . . . the chronic and incurable diseases produced by railway accidents should remain altogether unobserved, and that no cases have been placed on record to tell what is the pathological basis of the symptoms? How is it that these diseases of the spinal cord are, if we mistake not, rarely or never seen in the special hospitals devoted to them, and that at such a hospital as the National Hospital for Epilepsy and Paralysis, in Queen Square, with its justly distinguished staff, they should be well-nigh unknown?"

Another authority says: "I cannot now, after thirty years of hospital and private practice, call to mind a single case of concussion of the spine, arising from other accidents than on railways, which has had the terrible after-history that is so often attributed to them; and I have seen in that time many cases of spinal injuries of all kinds.

"There is another fact of personal experience. I have examined many cases of claimed irreparable or serious injury to the spine in private, both for plaintiffs and defendants in impending suits, but I cannot remember a single application of a patient for admission to the hospital to be treated for the after-effects of concussion of the spine, the original injury having been received in a railway collision."

Mr. Erichsen was not unmindful of this apparent hiatus in his argument, and he thus dealt with it:

"But, as in these cases of spinal concussion the symptoms are remarkably slow in their development and chronic in their progress; as the patient will live for years in a semi-paralyzed state, during which time the original cause of his sufferings has almost been forgotten; as he seldom becomes the inmate of a hospital—for the chronic and incurable nature of his ailments does not render him so much an object for such a charity as for some asylum or private benevolence; and as the cause of his death does not become the subject of investigation before a coroner's court, there is little opportunity, reason, or excuse for a *post-mortem* examination of that structure which is probably the one that is least frequently examined in the dead-house, viz., the spinal cord, as it is the one the correct pathological investigation of which is attended by more difficulties than that of any other organ in the body. Hence it is that, as in most other chronic diseases that are only remotely fatal—as in cases of hysteria, neuralgia, and in nine-tenths of those of epilepsy, we have no opportunity of determining in cases of concussion of the spine very remotely fatal, what the anatomy of the parts concerned would reveal of the present cause of the obscure and intricate symptoms presented during life." This explanation, though sound so far as it goes, can hardly be regarded as adequate.

Whether or not disease of the spinal cord is ever produced by mere concussion, it certainly may be caused by a severe blow upon the back. Page records a terrible case of this kind. The patient, a thin, delicate man aged twenty-nine, was thrown to the floor of the railway carriage in which he was a passenger, and a very heavy man fell on top of him, "right in the middle of his back." "He could give no clear account of the accident, saying he was dazed and could not stand. He was confined to bed for about a fortnight, suffering much from pain in his back and legs. He then improved a little, and was with to go to a hydropathic establishment in the country, where he stayed for two months. His back continued to trouble him very much (this is in his own words), but otherwise he improved. Toward the close of this two months the weakness which he had all along felt in his legs became a much more definite loss of power, and in a week or ten days he was unable to walk. Ten months after the accident there was no mistake as to his condition. Loss of power to move, and almost entire loss of sensation in his legs, paralysis of bowel, paralysis of bladder with alkaline urine, bedsores, and reflex spasm of the lower limbs, were the undoubted symptoms of softening of the spinal cord. His pulse was frequent, and his temperature above normal. He complained of pain in the lower part of the back, but there was no marked tenderness. He lingered for some months without improvement, and then died." Unfortunately, a post-mortem examination was not permitted. Mr. Page's comment on this case is that "without any visible signs of damage to the spine, there may well have been some separation of vertebræ, or some undue bending of the column, which, damaging at the same time the membranes of the cord, or causing slight intraspinal hemorrhage, was the real starting-point of the mischief which supervened." It is to be noted that in this case two months elapsed after the accident before there were indications of injury to the spinal cord.

Although investigation tends to disprove the existence, or, at least, the frequent existence, of "railway spine" in the sense in which Erichsen used the phrase, yet it shows how complex, obscure, and baffling are the injuries to the nervous system which may be sustained in accidents. Nor does the difficulty end here. Besides the injuries themselves and what may be called their legitimate results, the physician, as a practitioner or as a witness, has to deal with the superadded effect exercised by the will or by the imagination of the patient in view of his possible "damages." There are, from the medico-legal point of view, at least five classes into which cases of injury from railroad or other accidents may be divided, excluding those where some organic or structural change is apparent, namely:

(1) A general break-down of the system, ending sometimes in death, but usually in recovery more or less complete.

(2) A functional disorder, hysterical or otherwise.

(3) A real injury, but recovery is retarded intentionally by the patient.

(4) A real injury, but recovery is unconsciously retarded by the patient under the influence of prospective damages.

(5) The real injury being a trifling one, paralysis or other symptoms are feigned by the patient.

In classes 1 and 2 the prognosis is extremely uncertain, and the damages awarded in such cases must often be either more or less than the ultimate result of the injury would have justified. In the remaining classes the difficulty of discriminating between the disease which the patient really has, and that which he thinks he has or pretends to have, is very great, and even in those cases where, as Charcot said, the trouble is "hysteria, nothing but hysteria," the suffering may be none the less real, and recovery none the less uncertain. The possible gravity of the hysterical condition is a fact which may now be considered as established in medical jurisprudence. Many examples of the various classes just enumerated are given in the books. Page relates a striking case which would fall under class No. 1:

"A man forty years of age, of exceedingly delicate physique, was in a collision at night. The accident was a slight one, and he was the only passenger injured. He was said, in the official report, to be 'severely shaken,' but he was able to go on home. The next day he was delirious, and on the third day he was still talking somewhat incoherently. He complained of being much shaken and of feeling seriously injured, but there was no external appearance of bodily hurt. He improved for a time, and his condition was not thought to be serious. He never seemed, however, to make any marked progress, and four weeks after the accident he became more prostrate, and greater anxiety was felt about him. From this time he gradually got weaker and weaker, and died on the thirty-seventh day. No organic disease whatever was found on post-mortem examination in any of the viscera. The lungs were greatly congested, and the cavities of the heart were distended with blood, as if death had occurred from failure of respiration and circulation.

"The accident was regarded as the unquestionable cause of the death. Though moderate in character, it no doubt exercised a very unusual influence in depressing vital powers—never very strong naturally—and finally inducing such an amount of nervous exhaustion as to terminate fatally, even though there were no evidences before or after death of physical injury to any one part."

This case did not fall under the observation of Page himself, who states that he has seen none similar to it in the course of his practice, but he reports it on the authority of a "distinguished surgeon of vast experience in railway cases," from whom also the following instance is derived: "An apparently strong and healthy girl, nineteen years of age, in good position in life, was in a most serious collision. She received no bodily injury, but on the night following the accident she awoke screaming that the engine was rushing into the room. Her illness followed much the same course, and she died in about five weeks, no structural disease whatever being found after death. The brain and spinal cord were examined in both instances."

Usually, of course, the patient ultimately recovers from this depression of the vital forces, but the recovery is not always complete. Dr. P. C. Knapp says: "After severe concussion, or the psychical trauma of injury, the victim is thrown into a pronounced neurasthenic state, which may last for years. His nervous system is utterly shattered, or, to use the phrase of the day, he is all 'broken up.' He is nervous, emotional, irritable, perhaps hysterical; he is overcome by trifles; he is exhausted by the slightest effort. He may present no objective symptoms, but he remains an utter wreck. . . . The symptoms may be milder. . . . The patient finds himself changed; instead of being capable of continued exertion or strain, he is easily upset, trifles annoy him, he is irritable and quick-tempered; he has lost the power of rebounding after pressure, of maintaining the calm, good-tempered spirit which perhaps he had before; his sleep is not so sound, he starts when a door slams, his children annoy him, he is fretful and fault-finding. It may be that such a man is able to work as well as before, and to earn as much money, but if he be in some responsible position, perhaps his judgment is less sure, or his bearing toward his associates less agreeable; he is no longer a 'good fellow,' but nervous and disagreeable. These things, of course, are trifles for which no jury would award damages, but they are trifles which mark an enfeebled nervous system, and it is these very trifles which are like sand in the bearings of the carriage; they decide whether life is agreeable or disagreeable, and they are trifles which may continue for years; in fact, the man may never recover his old buoyancy, his consideration for others, and his good-nature."

It is a mistake to suppose that a jury would not award damages for such "trifles" as Dr. Knapp points out; they certainly would be justified in doing so, and although it might sometimes be difficult for a jury, or even for a physician, to discriminate symptoms of nervous disorder or enfeeblement that were real from those that were imaginary or feigned, yet the possible existence, and, what is more, the frequency of such cases as Dr. Knapp has described, should be recognized in courts of law.

In fact, the more the subject is examined, the more clearly is it seen that hysterical affections or conditions resulting from railroad accidents are often severe and lasting. Putnam observes on this point as follows: "So marked is the influence of nervousness on the subjective symptoms that it has been even maintained that, in a large number of cases of concussion of the spine, the symptoms are of hysterical origin." . . . But, on the other hand, it is necessary to avoid the danger of overestimating the effect of mental influence, and of regarding as entirely due to this, symptoms which are real and are merely intensified by attention. The danger is especially great in cases of railway injuries, concerning which an unbiassed judgment is not easy to secure, and in which, when objective symptoms are absent, it is easy to minimize suffering and attribute too much to the mental condition."

"The sinister influence of litigation on the intellect may be traced very widely. I believe that it is rare for symptoms to be purely mental. It is often asserted, by those employed for railway companies, that subjective symptoms quickly subside when the sufferer's claims are settled, but in a good many individuals whom I have had the opportunity of observing, long after they had received their 'damages' (as the expression curiously runs), this subsidence had not occurred, and even the 'sovereign balm' of substantial compensation has appeared to do very little for the relief of the sufferer."

It is probably the case almost universally, even when the patient is not feigning, that his recovery is retarded while a settlement or trial of his suit for damages is pending. Consciously or unconsciously, he resolves to get well no faster than is necessary. The important part played by the will and by the imagination of a patient is illustrated by the following remark of a distinguished surgeon:

"Many times, when to a passing observer the state of a patient (after operation) has appeared to be in every respect satisfactory, I have seen the sister at St. Bartholomew's shake her head and heard her say, 'He would do very well if he were not so nervous; but he will never get better while he continues to persuade himself that he cannot;' and rarely has the prediction been proved to be false."

Beside those cases in which disease or injury is simulated, there are others where real symptoms or defects are falsely ascribed to railroad accidents. Page gives an instance in which the patient, a publican, advanced in years, insisted that an enlarged prostate was due to a railway collision. In another instance an impostor, who in some unexplained way had really lost all tactile sensation over the mucous surface of his nares, pretended that the injury had been sustained in an accident which happened long afterward. Sometimes the patient himself is deceived, as in the following case, also related by Page:

"A shoemaker, seventy years of age, came to St. Mary's Hospital, complaining of pain over the right side of the thorax. When he had been stripped, it was found that he had lateral curvature of the spine to an extreme degree. He said that this condition was of quite recent date, and that he had only noticed it since he felt the pain. Judged by itself alone, his story was enough to cause alarm, but it was clear, both from the ossification of his costal cartilages and from the fact that not a single cubit had been taken from his stature, that this spinal curvature was old, in all probability nearly as old as the man himself. Had it been an acute change at this time of life, and had the pain which brought him to the hospital been due to the curvature, or been a symptom of some serious malady which lay behind it, a simple liniment and a tonic would not have restored him in a short time to his usual state of health. True, in this case there was no desire to impose; but how readily, in other circumstances, might such a deformity have been used as the foundation of a fraud!"

If the experience of prison surgeons could be consulted, numerous examples of malingering would doubtless be revealed which might throw light on some railroad cases. In the Massachusetts State Prison a criminal once lay on his back for two years, asserting that his legs were paralyzed and that he was unable to move. Despite this long-continued inaction, and notwithstanding that he endured the galvanic test and the insertion of needles in his skin, the physician in charge felt convinced that the man was perfectly sound, and he resolved to try a new experiment. He directed his assistant to prepare an operating-table close to the bed of the supposed paralytic, and to get together an imposing array of knives, saws, and other surgical instruments. This was done, and the tools were then sharpened and polished with great care and elaboration in presence of the prisoner When all was ready, he was laid upon the operating board, and bound tightly to it with numerous straps and cords. Finally, the surgeon came in, and, casting a hungry look at the patient, took up a large knife, and critically examined its edge. So far the prisoner had kept silence, but he could bear the situation no longer, and feebly asked what was about to be done. "I am going to cut off one of your legs," was the calm reply, "and if the operation is successful I shall remove the other one to-morrow." This was enough. "Let me up," said this paralytic of two years, "I can walk as well as any one." And so, in fact, he could. Page relates a similar case: "A prisoner took to his bed, complaining of great pain and swelling of the abdomen. Although the belly was enormously distended and tympanitic, there was no other sign of illness about him, and there was an entire absence of any one condition on which tympanites usually depends. After a few days' observation, and having carefully weighed all the facts of the case, the surgeon came to the conclusion that the man purposely induced the distention by swallowing air. Loudly enough for the prisoner to hear him, he accordingly whispered to the warden, 'When I come to-morrow I shall bring an instrument to tap him.' On the morrow the tympanites had disappeared." The same method of imposture is said to have deceived a board of French medical officers, a citizen, who had a similar faculty of distention, having obtained relief from military service by presenting himself in an enlarged condition, with clothes made for the occasion.

At the Massachusetts State Reformatory, not long ago, there was a shrewd criminal, gifted with a strong will, who declared that he had entirely lost the use of his legs, and was unable to walk even with crutches. The keepers and his fellow-captives were convinced that the man spoke the truth, and he was conveyed about tenderly by four convicts, on one occasion being brought to chapel in this manner, and carried up to the altar, where he received the communion before the assembled prisoners. This patient also endured the usual experiments with the galvanic battery and with needles, betraying no indication of feeling in his lower limbs. Nevertheless, the surgeon to the reformatory, who had received the man in this condition from the hospital of the State Prison, became convinced by careful observation that the fellow was shamming. The reformatory authorities and the prison commissioners thought this a great injustice. Before long, however, it became apparent that the paralytic, who had now become able to get about with the aid of crutches, was making a good deal of trouble among the other prisoners, and, a specialist being called in, the reformatory surgeon's diagnosis was confirmed. It was therefore resolved to send the man to the House of Correction, where he would be put at hard work, and this decision being communicated to him, the patient, seeing that the game was over, threw away his crutches, and walked upstairs as well as anyone.

These examples show with what perseverance and even with what fortitude men will simulate paralytic or other symptoms, in order to escape hard work, or to defraud a rich defendant.

It remains only to consider whether there is anything special in the nature of a railroad accident; is there, in other words, any medico-legal presumption that its effects will be particularly severe or lasting? "Spinal concussion or shock from railway collision," says one authority, "does not differ from forms of the same injury received in other ways. It is absurd, therefore, to give a particular pathological history to so-called railway spine." This is true, of course, in a sense, but in a sense it is not true. The horror and fright produced by a railroad accident are, as a rule, much greater than similar emotions which are felt in other accidents. The spectacle of those who are mutilated or dead, the cries and groans of the wounded, the shrieks of women and [illegible] as much as often added the [illegible] of the [illegible] and the escape of steam from the locomotive—all these elements increase the effects of personal suffering and apprehension. The cases previously mentioned, and others which might be cited, show that the mental shock of a railroad accident is sometimes sufficient to cause death. Cases where mere fright has this result occur now and then, and Sir Astley Cooper mentions one instance in which sudden terror from great agony proved fatal.

If then death sometimes follows the mental emotion produced by a railroad accident, is it not reasonable to presume that nervous, hysterical, or neurasthenic states, brought about by a similar cause, are likely, other things being equal, to prove especially severe and lasting?[1]

There is another aspect of accidents on the rail which deserves more consideration than it has received, and that is their physical character. A very able and suggestive paper on this subject was published by Dr. Thomas Buzzard, of London, in the *Lancet* (vol. i., 1867, p. 389). The author divides the injuries which may be sustained from a railway collision into four classes. These are: (1) The results of constitutional shock and terror.

(2) The results of a direct blow from contact either with the body of a fellow passenger or with the framework of the carriage.

(3) The effect upon certain interior organs of the body due to their inertia when the body itself is suddenly stopped; and

(4) The jar or shock to the whole body received through the framework of the carriage.

It is with regard to classes 3 and 4 that Dr. Buzzard makes some new and valuable observations in part as follows:

(3) "When a sudden check occurs to the speed at which the train is moving and the passenger's body is prevented from advancing on account of the obstruction presented by a partition or some such obstacle, such of his viscera as are suspended in his trunk or so situated as to permit movement will, in obedience to dynamical laws, continue their acquired motion so far as their attachments permit. The brain, filling as it does the cavity of the cranium, would not probably be so much influenced by this; but the spinal cord, being disproportionate to the size of the vertebral canal, would necessarily obey this law. A certain amount of strain is therefore placed upon the structures—nerves, ligaments, etc.—by which the cord is held *in situ*. The same holds good of the heart and its larger vessels, and more or less of the abdominal viscera; the strain thus occasioned may or may not be great."

The fact that concussion of the brain has never been associated particularly with railroad accidents, notwithstanding that this organ is less heavily guarded with bone than the spinal cord, has often been advanced to show that concussion of the spine is also unlikely to result from the same cause. But in the remarks just quoted Dr. Buzzard states a reason why the spinal cord should and the brain should not be susceptible of injury from railroad accidents; and in the following passage, dealing with the effects of jar communicated by the railroad carriage to the human body, he brings forward another reason which tends to the same conclusion:

(4) ". . . . If we imagine for a moment such a degree of violence as just falls short of exhausting itself in splintering the carriage, we can conceive the existence of an extremely potent source of injury to the human frame. . . . The elasticity of the soft structures [illegible] placed where these cover the body diminishes materially [illegible] the influence of any shock received at these particular points. But there are parts of the frame—notably the spinal column—where this protection is wanting, and nothing intervenes to prevent the shock influencing the passenger's body as it does the woodwork of the carriage. [illegible] the familiar illustration of the wineglasses and the [illegible] broken [illegible]. . . . So it has not unfrequently happened that passengers have scrambled out of the wreck of a smashed railway carriage unhurt, while others occupying a carriage which has escaped destruction have been seriously damaged by shock. . . . The enormous momentum of a heavy train, even when moving at a comparatively slow pace, is very apt to be forgotten. A train of 200 tons weight moving at 4 miles an hour will have a momentum equal to that of a train of 20 tons going at 40 miles an hour. When we hear, therefore, of the very slow pace at which a certain train is stated to have been moving when an accident occurred, it is necessary to know something of the length of the train, and consequently its weight, ere we can form an estimate of its momentum."

This, the dynamic branch of the subject, as it might be called, deserves further investigation.

Upon the whole matter it is difficult to come to any conclusion much more definite than that reached by M. Taine in a certain historical inquiry. After describing the conquest of all France by the Jacobin Club, he says: "So far I have discovered but a single principle, and that is so simple that I scarcely dare to state it. It is comprised in this one remark—human society, and particularly a modern society, is a vast and complicated thing." So we may say that the subject of spinal diseases and nervous affections resulting from railroad accidents is an extensive and complicated one. Organic injuries, varying from degeneration of the spinal cord, with its terrible consequences, to a mere strain of muscles in the back soon to be recovered from, are all to be met with; and as their first symptoms are often much alike, organic disease has again to be discriminated from functional disorders, and these in turn assume a thousand forms. Finally, the part played by the imagination or by the will must be ascertained, and true conditions distinguished from those which are feigned partly or wholly. The worst that Erichsen described may happen, and the malingering which Page detected is certain to be repeated. To do justice between plaintiffs and defendants in cases that relate to this matter will almost always be difficult and often impossible, but the prejudices by which the subject was obscured have very nearly disappeared.

Henry [illegible]

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[1] [illegible] Lancet, vol. ii., [illegible] p. [illegible]

[2] [illegible] Boston Medical and Surgical Journal, September 6, [illegible]

CHRONIC CATARRHAL INFLAMMATION OF THE NASAL PASSAGES.

ETIOLOGY.—The origin and mode of development of acute and chronic catarrhal inflammation of the upper air tract have been discussed at length elsewhere (Vol. IV. of this HANDBOOK, p. 400 *et seq.*), and the remarks found under the section Chronic Laryngitis (Vol. IV., p. 411) are equally true of chronic inflammatory disorders of the nasal passages.

Before passing to the consideration of the peculiar features of this particular form of inflammation, it may be interesting to review, as briefly as possible, some of the more important hypotheses which have been advanced concerning its essential nature.

THEORIES WHICH FROM TIME TO TIME HAVE BEEN HELD CONCERNING THE NATURE OF CATARRHAL INFLAMMATION OF THE UPPER AIR TRACT.—Reference has been already made in another portion of this work (Vol. IV., article Larynx, Catarrhal Affections of the) to the doctrines of the ancient physicians, their long continuance, and final overthrow by the labors of Van Helmont, [illegible] and Schneider. As a matter of historical interest, it may be well to give a brief résumé of the crude hypotheses which for centuries were accepted as gospel by the entire medical world.

In the earliest medical records we find catarrh, as its name indicates, regarded as a kind of falling down from the brain of a peculiar flux or rheum. According to many, during the process of "concoction" a crude distemper was generated in the stomach, by means of an inordinate heat derived from the liver, which ascended to the ventricles and pituitary gland of the brain through the veins and arteries (chiefly as clouds of vapor). According to others, the noxious material was generated primarily in the brain. The latter organ, which was supposed to be of a cold and moist nature, and therefore adapted to the formation of cold phlegm, and which was variously likened to the head of an alembic, the cover of a boiling pot, a sponge, a cupping instrument, a wild cucumber, and a mushroom, was supposed to condense the clouds of vapor and shower them down upon the parts below "like showers of rain." Some likened the head of man to the sun, as possessing an especial affinity for vapors, while others, following Galen, compared it to a smoky house. Aristotle, in his "Problems," propounded the question why man was more liable than other animals to catarrh, and assumed that the erect posture favored the descent of pituitous particles to the parts below. Schneider devotes an elaborate chapter to the refutation of this absurd idea. The method of escape of the matter thus manufactured or condensed in the brain gave rise to many varying hypotheses. While some held that it passed out from the sinuses of the corpus callosum through the mammillary processes and cribriform plate, others maintained that the cells of the sphenoid bone were the channels of exit; while still another class of observers believed that the nerves of the nose and throat, and those of the spinal cord, were the avenues through which the pituita descended from the brain.*

As was mentioned elsewhere, Van Helmont was one of the first bold enough to handle with pitiless satire the universally accepted doctrines of Hippocrates and Galen. He declared "that the large catalogue of diseases imputed to a distillation of rheum from the head to the toes and extremities, without any obstacle impeding the descent, is an old wives' fable invented by the common adversary of mankind on purpose, lest the causes of diseases being known, the remedies might at the same time be revealed," and that "the gray-haired dreams of the Grecians have drawn the whole Christian world after them into a servitude that is ridiculous, lying, and pernicious to humane society." (Those interested in the subject will not fail to be amused by the "Deliramenta Catarrhi" of Van Helmont. Describing the accumulation of the deluge of phlegm in the head, he likens it to a standing pond, "from whose oppression the brain is not able to deliver itself, neither by the aqueducts of the nostrils, nor the laborious pump of coughs. Oh, then," says Van Helmont, "instantly follows a stupid drowsiness, an inexpugnable propensity to outsleep Endymion, catoches, a lethargy, vertigo, apoplexy, loss of memory, and perdition of senses." Speaking of concoction, and the odors supposed to arise from the process, he dwells on how horribly offensive we would be, and adds: "Our very breath also, continually blasted with them, would save us the trouble of foreign poisons, disparage the fatal emissions of the basilisk, and be as dangerous to conversation as the fumes of the Lago di Tripergola," etc. As might be naturally expected, Van Helmont had many imitators, among whose works may be especially mentioned the essay of Conrad Horlacher.[1]

Before passing to the consideration of more modern views concerning the etiology and essence of catarrhal affections, it may be interesting to pass in review the various theories entertained by some of the chief directors of medical thought during the sixteenth and seventeenth centuries.

In the first half of the sixteenth century, the views which chiefly obtained were those derived from the occult medical philosophy of Paracelsus. In the quaint language of the Prince of Empirics, coryza and allied affections are due to the liberation of a salt, called "tartar," from its stronghold in the blood and its distillation to what was termed the region of Mars, or the naso-pharyngeal emunctory. This latter excretory being closed by a copious accumulation of tartar, the salt, not finding a sufficiently free exit, erodes the membrane and flows backward to the fauces. The saline liquid flowing from the veins of the "region of Mars" was supposed to irritate the membrane during its discharge, thus accounting for the inflammatory condition of the nasal passages and the frequently associated redness of the external nose. Nasal and throat hæmorrhage were ascribed by Paracelsus to a too great liquidity of the blood, by virtue of which its natural consistency was destroyed, so that it could not be contained within the vessels; and that its exit was furthermore facilitated by rupture of the vessel-walls by a volatile sulphur, which, loosed from its chemical bonds, expanded with such rapidity and force as to burst the tunics of the veins.

Toward the close of the century, and at the beginning of the following, the grotesque chemical theories of Paracelsus were supplanted by the more fantastic and curious chimerical conceptions of Van Helmont. Inflammations of the nasal passages and throat were believed to arise from the glowing or incandescence of the Archæus, a mythical demon or spirit, whose chief abode was in the stomach, and who, when the nose was irritated by any foreign matter, flux, or anything which deranged its nutrition, became so incensed that it established an inflammatory process at the area of irritation—placed, to use the metaphorical language of that period, a fiery seal upon the part as the symbol of its wrath and indignation. Nature was then supposed to send a modifying spirit, called the Latex, or source of serous humidity, to correct the anger of the Archæus and the impression made from without by the air, etc. (*influent spirit*, impetum faciens), and in this way the discharge originated.* Hæmorrhage was thought to result from the liberation of an "acor" in the blood, which so enraged the Archæus that it broke through the walls of the vessels.

Toward the middle of the seventeenth century a new doctrine was announced by Francis de la Boë, or Sylvius, as he is more commonly called, of Amsterdam, afterward the famous clinical teacher of the University of Leyden. One of the first to accept the doctrines of Harvey, he repudiated the fanciful Archæus of Van Helmont, and announced a theory based on more exact anatomical observation. Sylvius explained the phenomena of catarrhal inflammation solely by the laws of chemistry. His theory, which may be termed the chemico- or physio-pathological theory of catarrh, may be briefly stated as follows: Nasal polypus and sarcoma (hypertrophic catarrh) † result from an active determination of nutrient blood, as the case corrected by a peculiar acid generated in the glandular secretions (lymphs). The fibrous or harder structures of the membrane, eroded or ulcerated by the corroding acid, receive a greater supply of blood, which leads to [illegible], through [illegible] action, by the acid lymph into swelling and [illegible] generation. The simple inflammatory condition of the [illegible] and the redness of the external nose, from which catarrhal patients suffer, were due, he thought, to [illegible] and [illegible] of blood, brought about either by some effervescing [illegible] carried to the parts with the blood, or from the [illegible] of a [illegible] acrid [illegible] substance which [illegible] this part "as a fire." In the disease called coryza, he maintained that the external air so affected the "conglomerate glands" [illegible] of the [illegible] plexus and lateral [illegible] as to cause [illegible] of their peculiar humors, and accounted in this way for the acrid taste of the secretion in the disease. Hemorrhage from the nose and throat was due, he thought, to [illegible] rupture of the vessels from [illegible], [illegible] or [illegible] of the blood, [illegible], swelling, [illegible], etc.

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* The above is, of course, the merest outline of the views held by the writers of antiquity. Those desirous of pursuing the subject further will find the best ancient account of it in the third book of the *De Causis Symptomatorum* of Galen. A good *résumé*, based mainly on the observations of the ancients, was published about the middle of the sixteenth century by Sebastian Paparella (*De Catarrho, Papiæ*, 1562). It is curious to note that in this book, which contains much that is good mingled with crudities and absurdities of doctrine, Paparella refers (pp. 114-115) to the debilitating effects of summer, which, he thought, "rarefies the channels of the head," and causes thereby the accumulation of much excrement, etc. A very elaborate account of the views held by his predecessors and contemporaries is also given by Schneider.

* The following passage from Van Helmont may possibly be of interest: Describing the latex, he observes: "It comes to pass not seldom, that the latex, contaminated by the admixture of some foreign salt, doth therewith infect the influent spirit, so that it becomes degenerate from its requisite simplicity and purity, not by injury from the air, etc., but from a breath or blast of *contagion* conceived in the *part affected*."

† It is only within a comparatively recent period that the hypertrophic enlargements of the turbinated tissues have been relegated to their proper anatomical place among affections of the nasal passages. The ancients probably knew of their existence, but confounded them with polypi: the Greeks under the terms "hypersarcosis" and "sarcoma," the Romans under the appellations "carnis excrescentia" and "germinatio." It is unnecessary to invoke the long list of ancient writers, from Hippocrates down, in defence of this proposition, but I will simply direct attention to the following words of Actuarius as a fair presentation of the doctrine of his day: "Polypus, est meatuum, qui a colatu ἠθμοειδεῖς (quasi dixeris colatorios) vocantur, obstructio, propter carnis excrescentiam, quæ ea parte ita inhæret, ut ægrè detrahi possit. Fiunt enim frequentes germinationes, quæ instar polyporum, naribus circumcirca adfixæ adhærent quibus inspiratio expiratioque præcluditur, et siquid superne pituitæ aut muci defluit haud facile obstante polypo delabi potest."[2]

A distinction was made by some[3] between true polypus and other "caruncles" found in the lower and more fleshy parts of the nose, and Janus[4] draws an accurate differential parallel between "ganglia" (evidently the hypertrophic turbinated tissues of the present day) and polypi in the following sentences: "Credo vero differentias posse inde hauriri: primo ganglia semper deprehenduntur in naribus in partibus inferioribus. Polypus vero frequentius adnascitur in partibus superioribus; dein circa basin semper sunt crassiora et per latera, contra polypus magis est attenuatus imo sæpissime pensilis. Tertio ganglia sunt duriora. Polypus vero mollior. Carnositas vero atque duritas distinguntur a ganglio, quod ganglium ut plurimum retineat colorem eundem cum partibus vicinis; polypus contra aut nigrescat aut colore præditus sit livide."

While Sylvius was expounding his views at Leyden, his contemporary and fellow iatro-chemist, Thomas Willis, was introducing in London a theory which, although differing essentially from that of Sylvius, nevertheless resembled it so far as it was based upon similar iatro-chemical principles. According to Willis, coryza and polypus arise from obstruction to the nervous fluid and its consequent stagnation in the nose, where evaporation of the more spirituous components takes place, and the fixed particles remain behind as a solid mass. The simple inflammatory conditions of the nose and throat result from effusion and damming up of blood from the arterioles under the surface, with retention of many saline fixed particles, especially the acid constituents of the blood. Hence arise swelling, redness, and fever. Coryza is due to a serous catarrh effused from the blood in which the "tubulated membranes" and the processus mammillares and the nasal structures are included. This copious fluid so fills the pores and meatuses that it is squeezed from them "as from a sponge," and as the result of the compression the matter either exudes into the nasal passages, or is transmitted through them to the palate and fauces. Willis's ideas of nasal hæmorrhage were considerably in advance of those of his predecessors, doubtless from his more perfect acquaintance with anatomical and physiological science. He considered that hæmorrhage arose from a vice of the blood (plethora, acrimony, etc.), blood-vessels (laxity of fibres, patency of mouths, etc.), or both, or from imperfect transfer of blood from artery to vein, as in the scorbutic and cachectic; or, finally, from spasmodic or convulsive affections of the motor fibres.

The effect which the philosophical speculations of Descartes produced on the theory of medicine are sufficiently well known; and hence it is not surprising that there were not wanting those who applied his doctrines in explanation of the phenomena of inflammation. According to the Cartesian school, coryza and allied affections are due to "acute" acid or acrid particles floating in the air, and vellicating the fibres of the membrane which invests the nares. The lymphatic vessels receiving the stimuli, pour out a liquid so sharp that it erodes the parts it flows over, and so copious that it flows to the larynx and fauces, and gives rise to hoarseness and cough. The acridity of the discharge also occasions sternutation.

The space allotted to this article does not permit an extended review of the many modifications of the hypotheses detailed above, and I shall therefore only indicate the state of medical thought on the subject at the opening of the last century. According to [illegible], who may be regarded as representative of that epoch, the humors (blood and other juices) enter into the mouths of the smaller vessels, which they dilate, and in time obstruct them [illegible]. Hence arise [illegible], swelling, redness, and pain. The constantly dilated and distended vessels do not readily return to the normal state, and therefore in winter time the blood and other contents present an obstacle to the circulation, and cause the individual suffers a return of his malady. Should the obstruction and retention of humors exist for a long period, an increase in volume of the part affected may take place and a polypus thereby result.*

At the close of the seventeenth century Michael Ettmüller looked upon catarrh as a preternatural degeneration of the lympha or blood serum, and considered the orifices of the lymph-glands, distributed by Steno in the membranes, as the seats of these diseases.†

Passing now to the middle of the next century, we have the first detailed advance made by F. Hoffmann (see article on Larynx, Catarrhal Affections of the), who declared that catarrh was the local expression of a general febrile state, and that the diseased condition of the mucous membrane was produced by the acrid character of the lymph or serum, which was eliminated as a critical discharge from the glandules. Hence arose the inflammatory catarrh or fever of the last century.

Later on Pinel (see Larynx, Catarrhal Affections of the) taught that catarrh was an inflammation or exaggeration of function of the mucous membranes. In Great Britain the inflammatory theory was supported mainly by Cheyne, while in France Laennec held that the nature of catarrh was still in doubt; that in certain cases it resembles a highly inflammatory affection, while in most others it presents the characters of a simple congestion, and in some indeed those of a passive or atonic congestion.

Passing through the era of Broussaisism we now come to the year 1791, when a curious theory was propounded by Théophile de Bordeu. Bordeu argued at great length that catarrh was an inflammation of the cellular tissue of the body, and endeavoured to reconcile this view with the doctrine of Hippocrates. The lungs, pleura, etc., were compared by him to a cellular pyramid, which formed the nidus for the diseases called catarrhal. The whole cellular tissue formed a vast, so to speak, connective or sympathetic chain, so that inflammation of one part might be felt in organs far remote, as, for example, in the pathological connection between diseases of the rectum and throat.

In the early part of the present century Erhard Schäffer maintained the thesis of an intimate relationship between catarrh, rheumatism, and the acute exanthemata. When the disease attacks a mucous membrane, it is catarrh; when a serous membrane, rheumatism.‡

Shortly after Schäffer wrote, Schönlein advanced the idea that catarrh was a true blennorrhœa, and looked upon the copious flux as the leading and essential factor. A few years later his pupil Eisenmann reverted to the old doctrine of the rheumatic origin of the affection, and held that, through atmospheric influences a disturbance of the general capillary system was produced, which resulted in an exanthematous condition of the mucous membranes—in short, an erythema. In a subsequent work [12] he thus described the mechanism of the process: The impulse produced by the temperature causes a kind of shock to the peripheral excito-motor nerves, the lungs, or the stomach. This shock is directly reflected to the origin of the nerve in the cerebro-spinal apparatus. This reflex act then oscillates through the whole spinal cord, but generally causes a molecular change or disturbance of function in the nerve-root which is in nearest relation with the afferent peripheral nerves.

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* In the preparation of the historical section the following works have [illegible]: Sprengel: [illegible]; Haeser: [illegible], 1862; Sylvius: Opera medica, [illegible], 1680; Willis: Pharmaceutice rationalis, [illegible]; [illegible], Paris, 1793–1826; [illegible], 1791.

† It is a curious fact that [illegible] has taken [illegible] [illegible].

‡ The close relationship or identity of catarrh and rheumatism is generally a matter of common acceptance. [illegible] Sauvages, [illegible], Hoffmann, [illegible], Lancisi, Huxham, Stoll, and others. Among these, [illegible] considered that catarrh is [illegible].

The theory which attributed catarrh solely to secretory changes in the mucous membrane was combated, among others, by Canstatt,[13] in 1843, who maintained that of hyperæmia and stasis. A few years later, a novel idea was suggested by Schönbein,[14] a distinguished chemist of Basle, who, as the result of certain experimental researches, was led to believe that the presence of ozone in the atmosphere bore a definite relationship to the periods at which catarrh of the respiratory apparatus was most prevalent, and argued from this, and its irritating effect upon his own nasal mucous membrane, that therein lay the principal causative agency of the disease. Further investigation, however, demonstrated the fact that ozone acted only as a local irritant, like chlorine and other gases; while its supposed relationship to the so-called catarrhal months was subsequently overthrown by the observations of Seitz.[15] The rôle which the nervous system plays in the mechanism of this class of affections is well known and sufficiently obvious; and quite recently Woakes,[16] of London, has pushed the neurotic theory to its utmost extreme. Woakes bases his hypothesis of the origin of catarrh on the assumption that the ganglia of the sympathetic act as subcentres, bringing various tissues into reflex relationship by virtue of an inherent correlating power, by which the afferent impressions starting in a given tissue are reflexly referred to a totally different tract. Nasal catarrh is a neurosis of the cervical sympathetic ganglia, whose essential feature consists in an inability on the part of these ganglia to transmit reflexly the afferent impressions to the efferent vaso-motor nerves. A condition of perpetual vessel-dilatation is thus kept up in the tissues where the latter are distributed, as the result of which hyperplastic changes develop. The phenomena of "taking cold" are explained according to the above, and the general inference is drawn that catarrhal symptoms spread to contiguous regions because the adjacent structures receive their *nervi vasorum* from a centre (ganglion) identical with that which innervates in a similar way the regions primarily affected.

Contagion.—That the simple catarrhal affections of the upper air-tract, and notably coryza, are communicable by contact, is an orthodox popular belief which has obtained, chiefly on the continent of Europe, less so in our own country, for many years; while the idea of contagion by floating particles of matter in the atmosphere was implied in the doctrines of the Cartesian school. Several centuries ago Crato * adverted to the superstitious belief among the Germans that a coryza could be transmitted by drinking from a glass which had been used by one suffering from the disease; and later Bonnet[17] and Schurig[18] mentioned the same subject, without however bringing forward any clinical evidence to its support. In the "Ephemerides of Natural Curiosities,"[19] Standigelius tells the story of four children of a peasant, who were taken in the same week with a very fetid catarrh or ozæna. But the evidence here of contagion is altogether presumptive, and the possibility of the direct transmission of the disease is overthrown by the fact that when the malady broke out in all its fury the children were not together.

Years ago Dr. J. K. Mitchell, and later Sir Henry Holland, of London, and Mütter, of Vienna, advanced the theory that catarrhal disease was due to the action of a micro-organism, and more recently its parasitic nature has been urged by Dr. Austin Flint.[20] While certain clinical evidences of direct transmission apparently favor this view, it has, on the other hand, been completely negatived by the failure to produce the disease by inoculation.[21] Exact evidence is also wanting to establish the *epidemic occurrence* of acute simple coryza, except under the meteorological conditions which have been described in the article on the Etiology of Catarrhal Affections.

Classification.—The classification of the stages of chronic nasal inflammation given below is based on anatomical and clinical experience, and will, I venture to think, prove of practical value in the diagnosis and rational treatment of this affection.

The leading anatomical characteristic of chronic nasal inflammation resides in certain changes which the erectile bodies undergo. In the earlier stages of catarrhal inflammation there exists a peculiar excitability of these structures which causes sudden obstruction of one or both nostrils; later on is found a permanent swollen or puffy (dilated) condition of the erectile tissue, due to a subparalytic state of the intercellular walls with consequent dilatation of the erectile spaces. As the disease advances there is a metamorphosis of the intercellular walls into dense fibrous tissue, which, in contracting, gradually obliterates these spaces, and causes, finally, atrophy of the erectile bodies.*

These changes in the erectile structures furnish the anatomical ground for the classification which I present for consideration.

Classification of the Stages of Chronic Nasal Inflammation.—I. *Simple Inflammatory* (*Rhinitis Simplex*); divisible into periods of—

α. Irritability of erectile tissue.
β. Permanent dilatation of erectile tissue.

II. *Hypertrophic* (*Rhinitis Hypertrophica*); divisible into periods of—

α. Dilatation with hypertrophy.
β. Complete hypertrophy.

III. *Atrophic* (*Rhinitis Cirrhotica*); divisible in periods of—

α. Commencing atrophy.
β. Complete atrophy.

I. The first, or simple inflammatory stage, consists of two periods, the one characterized by abnormal irritability of the cavernous tissue, the other by permanent dilatation of the same.

α. Period of irritability: Characterized by increased irritability of the mucous surfaces, expressing itself chiefly in abnormal excitability of the erectile tissue, leading to sudden obstruction of one or both nostrils in the presence of changeable atmospheric conditions, when the individual assumes the recumbent position, as at night, or when under the influence of certain forms of excitement, and in some women at the menstrual period; in fine, when the individual is exposed to any of the exciting causes of coryza.

β. Period of dilatation or permanent puffiness of the erectile tissues (chronic coryza). As the result of the repeated erection of the cavernous tissues which occurs in the first stage, a paralytic or subparalytic state of the resilient and contractile elements of the walls of the erectile cells develops, leading to their permanent dilatation, recognizable by the eye as an engorged or puffy condition of the turbinated tissues, which may be distinguished from true hypertrophy by its collapsing under the probe, by the readiness with which it can be pressed against the external wall of the nostril, and by its diminution in bulk under various measures which produce reflex contraction, or emptying, or depletion of the erectile spaces, such as the sudden application of cold, the use of cocaine, etc.

It is this subparalytic condition of the tissue, represented by the puffy character of the swelling, which is the connecting link between the simple and the hypertrophic stages.

II. The second, or hypertrophic stage, is divisible into

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[*] Concil. et Epist., liber 2. p. 246, Hanov., 1595; quoted also by Hagens, Diss. de Coryza, Berolini, 1841, p. 21. Ettmüller (op. supra cit., p. 334) also alludes to contagion from nose to nose, and from the promiscuous use of cups and napkins.

[*] For further particulars concerning these changes, see article by the writer in the Philadelphia Medical News of October 4, 1884, entitled, Some Notes on the Pathology of Intranasal Inflammation.

two periods, characterized respectively by hypertrophy with dilatation, and by complete hypertrophy.

a. Period of hypertrophy with dilatation. Characterized by commencing hypertrophy of the intercellular connective-tissue walls of the erectile bodies, with uniform puffiness of the tissue not especially involved in the fibrous process.

b. Period of complete hypertrophy. Characterized by more or less complete conversion of the affected portion of the tissue into a fibrous mass; swelling generally uniform, non-shrinking. This complete hypertrophy is most commonly met with on the posterior extremity of the inferior turbinated body, while its anterior extremity is generally puffy and dilated, doubtless from collateral engorgement.

III. The third, or atrophic stage, is separable into two periods, one of commencing atrophy, and one of complete disappearance of the erectile tissue.

a. Period of commencing atrophy. Characterized by pronounced contraction of the newly formed fibrous bands, leading to an irregular, nodular condition of the tissue, most prominent in the posterior part of the inferior turbinated body and along its inferior border. This uneven appearance of the diseased portion not infrequently assumes the appearance of fibrous or papillomatous excrescences which may become detached, the process of detachment constituting one step in the future and complete atrophy of the tissue. The erectile spaces are inconspicuous, and, in some places, entirely gone.

β. Period of complete atrophy (turbinated cirrhosis). Characterized by a rudimentary condition of the turbinated bodies, due to more or less complete disappearance of the erectile tissue.*

SYMPTOMS.—The symptoms and rhinoscopic appearance of chronic inflammation of the nasal passages may be conveniently considered under three heads, corresponding to the three phases or stages of the disease—the simple inflammatory, the hypertrophic, and the atrophic.

Simple Inflammatory Stage.—The most prominent symptom of this stage is increased irritability of the nasal mucous membrane, which finds its most conspicuous expression in an abnormal excitability of the erectile tissue, which is found on the turbinated structures and septum. This irritability of the cavernous tissue constitutes the characteristic and central phenomenon around which the other symptoms of this stage are grouped, and from which many of them proceed, either from purely mechanical causes or as the results of reflex or vasomotor influences (see article on Nose, Neuroses of). The subjective expression of this condition is a more or less constant sensation of stuffiness or of a foreign body, and a tendency to temporary stoppage of one or both nostrils. This is usually most noticeable in the presence of changeable atmospheric conditions, when the individual assumes the recumbent position, as at night, or, sometimes, when under the influence of sexual or other excitement; and, in women, at the menstrual epoch. In fine, when the individual is exposed to any of the predisposing or exciting causes of the disease. In some persons the turbinated tissue is thus rendered so exquisitely sensitive to the slightest perturbation or vibration of the air that they can presage with certainty the approach of atmospheric changes by the sudden swelling of the nasal structures, as the twinges of corns can predict the coming of a storm.

Other things being equal, the tendency to stoppage is much more liable to occur in those of a pronounced neurotic temperament, but this can by no means be accepted as a universal law. There can be no doubt that direct irritation of the sensitive or olfactory nerves of the nasal mucous membrane, or an impression reflected from the eyes, or even other remote organs, leading secondarily to dilatation of the erectile cells and the filling of their cavities with blood, is the mechanism of the sudden obstruction of the nostrils, which is the leading characteristic of this stage.

The curious clinical fact that, in acute obstruction of the nasal passages, when the individual assumes the lateral position, the upper nostril becomes free, has never received satisfactory explanation. The theory usually accepted, of gravitation of blood to the most dependent portion, has always seemed to me unphysiological and absurd, and the more plausible explanation suggests itself, that it is a purely vaso-motor phenomenon, occurring possibly through a central impulse in response to the call of the respiratory sense.

The irritation and consequent swelling of the nasal membrane may be inconsiderable, and give rise to little or no inconvenience, or it may awaken phenomena of a reflex nature, such as sneezing, coughing, and various other neurotic conditions (see Nose, Neuroses of).

The result of this increased vulnerability of the mucous membrane is that the patient is constantly "catching cold," and the slightest change in the weather is often sufficient to produce stoppage of the nostrils, hoarseness, and ringing in the ears. He is unable to explain the tendency to sneeze in the morning, or the hoarseness which follows the prolonged use of the voice in speaking or singing. A more or less constant itching at the end of the nose is frequently referred to the crawling of a mythical stranger, and the mere suggestion of chronic nasal catarrh is stoutly, and sometimes indignantly, repelled.

As the result of the repeated erection or filling of the contractile tissues, a paralytic or subparalytic state of the resilient and contractile elements in the walls of the erectile cells develops, which leads to permanent dilatation, recognizable by the eye as an engorged or puffy condition, mainly of the turbinated tissues, which may be distinguished from true hypertrophy by its collapsing under the probe, by the readiness with which it can be pressed against the wall of the nostril, and by its diminution in bulk under the various means which produce reflex contraction or emptying or depletion of the erectile spaces (the sudden application of cold, cocaine, and allied drugs, etc.). It is this puffy condition which, as has been observed above, constitutes the transition period between the simple and the hypertrophic stages. Reflex phenomena are common at this period of the affection.

The *secretion* in the simple catarrhal stage varies greatly in quantity and quality. At first it is thin, inconsiderable, and inconstant, according to the condition of the surrounding atmosphere and the presence or absence of the exciting causes of the disease. Gradually it becomes more abundant, thicker, and annoying. It collects in the sinuosities of the nasal fossæ, and produces often a false sense of obstruction, which is relieved by the use of the handkerchief. At times it distils from the nostrils as a clear, almost limpid fluid; at others it collects in flaky, whitish-yellow masses, which adhere to the swollen, reddened mucous membrane beneath them, and which are most frequently observed on the anterior ends of the turbinated structures, in the middle meatus, and in the hollow of the septum; or, in other words, in those situations where they are with most difficulty removed by the expiratory forces. Occasionally, and especially in cases of long duration, the mucous membrane is covered with a multitude of little, whitish masses of secretion, which present a more or less mealy appearance. The secretion also varies in color from a dirty white to a greenish-yellow hue, and is not infrequently streaked with blood. Occasionally the discharge has a distinctly bluish coloration.

In persons in whom the neurotic element predominates, the discharge approaches the character of a true rhinorrhœa, and under these circumstances fabulous amounts of fluid are said to have distilled from the nostrils.

Impairment of the sense of smell and difficulty in respiration are unusual at this stage, their presence being determined by the location of the structures chiefly involved and the extent of swelling of the same; and this is also true of interference with the functions of audition and voice production.

The intranasal vascular changes are often shown in an unusual tendency to flushing of the apex of the nose, which in some persons becomes permanent. This redness of the external nose, which may be confined to the apex, or dorsum, or may spread from the latter across the cheeks like two crimson wings, is now and then observed in a number of members of the same family.

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* This classification was first presented to the [illegible], on April 4, 1886.

In long-standing cases, a veritable varicose condition of the vessels of the external nose develops. This varicose condition is especially well-marked at the entrance to the vestibule, and is sometimes associated with a similar condition within the nasal chamber. The redness of the nose which is frequently met with among habitual drinkers is often due to the catarrhal condition of the naso-pharyngeal passages which is common to chronic alcoholism; and the acne rosacea of this class doubtless frequently originates in a similar manner.

As the disease progresses, the follicles at the apertures of the nostrils become diseased, the vibrissæ are loosened, and become detached. Occasionally small follicular abscesses form at this situation, which are a source of great annoyance, and which, in some instances, are due more to the treatment than to the disease. Not infrequently, and especially in children and in neglected cases, the sharp, acrid discharge produces an eczematous or inflamed condition which may invade the whole upper lip. It may even happen that a sodden condition of the mouth and gums may result, and a patient under the observation of the writer attributed the loss of her front teeth to this condition alone.

The discharge varies greatly in amount. It is usually most conspicuous on arising in the morning, and may disappear during the day, or may be always present. It is either expelled through the anterior nares, or may gravitate or be drawn voluntarily into the pharynx, from which it is expectorated. The thicker the secretion and the richer it is in solid elements, the greater the tendency to adhesion to the mucous membrane, and the subsequent production of crust-formation. If it be allowed to remain in the nasal passages, decomposition occurs, a fetid smell and taste are imparted to it, and the expired air acquires a peculiar, sickening smell. A potent factor in the reflex expulsion of the secretion is the act of sneezing, and by this means much of the inspissated discharge is loosened from parts in which its dislodgement is exceedingly difficult or impossible by the simpler expulsive force used in what is commonly termed "blowing the nose." Examined under the microscope, the secretion contains a multitude of leucocytes, the remains of the degenerated epithelium of the nasal passages, blood-cells, granular débris, micrococci of decomposition of various kinds, and various objects derived from the external air. No characteristic germ has ever been discovered, and there is no microscopical evidence to show that catarrhal inflammation of the nasal passages is in any sense a parasitic affection.

In some cases, instead of an abnormal increase in secretion, is found exactly the reverse. The membrane presents a dry, almost shiny appearance, and the expired air is generally offensive. The character of the odor varies greatly, and seems in some instances to be due to individual peculiarity. Occasionally it has a singular earthy character, difficult to describe, but whose repulsive character, if once perceived, is never forgotten. Although the mucous membrane may be only slightly swollen, there is a more or less constant sense of false obstruction present, and the individual is constantly endeavoring to clean the nostrils of imaginary secretion.

The *rhinoscopic appearances* are those of diffuse or localized congestion, with varying degrees of inflammatory swelling, with the presence of secretion of varying character and quantity (see Symptoms). True ulceration rarely, if ever, occurs in simple chronic rhinitis. On the other hand, the epithelium may be detached through chemical or mechanical irritation, and we should therefore carefully distinguish between this loss of substance and that produced by the pathological process itself. Beginners frequently mistake small, isolated areas of dried, adherent muco-purulent secretion for losses of substance, an error that only needs pointing out to be avoided. Now and then the vessels of the mucous membrane present a more or less varicose and swollen condition, and small spots of hæmorrhagic infiltration may be discovered, the most frequent seat of which is the septum on the inner wall of the nasal vestibule.

Hypertrophic Stage.—There arrives, sooner or later, a time when the symptoms of the first stage become more pronounced. The patient becomes aware of a gradually developing difficulty of breathing through the nose. Sleep is rendered unquiet by the accumulation of mucus in the throat, and the individual arises in the morning with a dry throat and coated tongue. The organic matter of the buccal secretion is deposited on the teeth and gums, and collects and dries at the corners of the mouth; the breath is often offensive, and headache is complained of. Soon the lips become fissured and cracked, and the mucous membrane peels off; the general health, especially in children, begins to suffer; the appetite becomes capricious; more or less constant ringing in the ears, followed by gradually deepening deafness, is also common. These signs indicate an increase in the thickening of the membrane;—the second stage has been reached—the rhinitis has become hypertrophic.

When the symptoms of this stage are more closely examined, it becomes evident that obstruction of the nostrils from hypertrophic enlargement of the internal structures is equivalent to interruption of its functions as an organ of respiration, olfaction, audition, and voice-modification, and the phenomena to which it gives rise will therefore depend upon the anatomical seat of the obstruction, and the physiological properties of the structures that assist in its production. The symptoms of nasal obstruction are often so intricately blended with those of the conditions which complicate it that their explication would involve a review of the clinical history of the commoner affections of the nose, throat, and ear, and I shall therefore content myself with simply indicating the pathological results of an obstructive nasal lesion.

Obliteration of the upper meatuses or malformation of the nasal roof is accompanied by interference with the sense of olfaction and the varied train of morbid impressions which follow its perversion.* Over a century ago, Morgagni called attention to deflection of the septum as a not infrequent cause of unequal distribution of the nervous power of smell, and[22] related a case in which, from obliquity of the crista galli and consequent diminution in number of the olfactory foramina, this sense was supposed to have been less acute in the nostril corresponding to the narrower side of the cribriform plate. Just here let me observe that the ability to respire with freedom through the nose by no means negatives the existence of obstruction; the upper nasal chambers may be crowded with growths and the pharyngeal vault covered with vegetations, and yet respiration go on with perfect ease. This is a fact which is systematically and persistently overlooked by many practitioners of medicine, and the absence of obstruction is too often inferred from the passage of air through the nostrils when the mouth is closed.

Should the obstruction occur in the inferior meatus, the mouth becomes the channel through which the air passes to and fro from the lungs, and nasal is transformed into buccal respiration. From this transference of physiological relations it naturally follows that the air reaches the delicate lining membrane of the lower respiratory tract in a state unfit for respiration. Hence arise hyperæmia and chronic inflammation of the pharyngo-bronchial membrane, with their associated alterations in the voice.

Besides the part which the nose plays in olfaction, respiration, and voice-production, it also serves as the channel through which air reaches the middle ear. Hence, imperfect aural ventilation often occurs, with resulting otitis media, and sometimes perforation of the drum membrane and consequent otorrhœa. This same chain of events follows the obstruction of the Eustachian tubes by growths in the pharynx or the pressure of the hypertrophied nasal turbinated structures, or by inflammatory engorgement of the orifices of the tubes themselves. This not only cuts off the air supply from the tympanum by direct continuation of its natural channel, but also by interfering with the motions of the velum, and therefore with the opening of the tube for the proper relief to drainage of the tube. The intimate and direct connection of the blood-supply of the tube and pharynx with that of the middle ear and their anatomical continuity of tissue, favor, furthermore, the extension of the inflammatory process from the one to the other. Indeed, in very many cases the aural inflammation is merely a symptom of nasal catarrh, and gradually disappears without special treatment upon the removal of its primary cause.

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* See article on Nose, Neuroses of the.

Inflammation of the tube may result in stricture; and in long-standing cases of salpingitis fatty degeneration of the tubal muscles occurs with the consequences described above.

These are by far the most common causes of chronic catarrhal inflammation of the middle ear. There is still another way, however, in which morbid conditions of the nose may react upon the circulation and upon the nutrition of the aural chambers, viz., through the reflex agency of the vaso-motor and trophic nerves. I am led to the assumption of reflex irritation by the pain and congestion in the ear which occasionally follow the manipulation of instruments within the nasal cavities, or the application of caustics or other remedies to their lining membrane; and, furthermore, by the existence of symptoms referable to the ear (tinnitus, pain, etc.) which cannot be explained on any other hypothesis.

It is impossible to exaggerate the part which diseases of the nose play in the production of inflammatory conditions of the middle ear. Between sixty and seventy-five per cent. of all cases of ear disease originate primarily in morbid states of the naso-pharynx, and the successful treatment of middle-ear catarrh will in the vast majority of instances depend upon their recognition and removal. So important is their relationship that we may lay down the rule that *the examination of the ear should be begun, not with the inspection of the external meatus and tympanic membrane, but with the exploration of the nasal fossæ and retro-nasal space.*

The symptoms of advanced nasal obstruction from adenoid growths have been well described by Meyer and others. The pallid countenance assumes a dull, stupid expression, and the cheeks become flabby from elongation of the naso-labial sulci. The mouth is kept open, the lower jaw depressed, the gums are [illegible] and cracked, and saliva dribbles from the mouth. This often leads the parents of the child to connect the stupid countenance and the deafness which is nearly always present, with imbecility. Some writers call attention to the unusual prominence of the front teeth as a symptom of obstruction in the naso-pharynx, and Michel[20] observed in a girl aged eight years the inner canthi of the eye so depressed that her countenance wore a strange "Chinese" appearance. Deafness and tinnitus are nearly always present. Neuralgia is common. Taste is impaired; the nasal discharge is profuse, excoriating the nostrils, filling the pharynx, preventing sleep, and provoking suffocating attacks. These symptoms, together with constant snuffling, are well marked among children, and react most powerfully upon the general health. Several of my patients complained of a heavy dragging sensation in the back of the nose, which they compared to the presence of two heavy weights hanging into the throat. (The condition found was bilateral turbinated hypertrophy.) Later in life the nostrils become abnormally narrow, from arrested development or collapse of the alæ nasi. "The speech becomes nasal, the tone of the voice dull and 'dead'" (Meyer). The voice is furthermore weakened and rendered indistinct by the interference with the mobility of the soft palate from the presence of tumors and hypertrophies of the turbinated bodies. Obstruction in the nasal fossæ (deflected septum, polypi, etc.) prevents the free passage of the voice and diminishes correspondingly the force of the tone.

Rhinoscopic Appearances.—If the nasal passages be examined at this stage they will be found obstructed by enlargement of the turbinated bodies (generally the inferior) and thickening of the mucous covering of the septum.

When the hypertrophy is anterior the diagnosis can be made by inspection of the anterior nares, and in some cases the deeper regions of the nose, and even the Eustachian tubes, can be seen with the aid of a strong light and special inspection apparatus. To the practised touch the probe is often an important auxiliary in the detection of posterior hypertrophies, but all such manipulation is rendered unnecessary by the ease with which the posterior nares may be examined by reflected light. Anterior hypertrophy appears as a smooth, globular, or [illegible] sessile mass causing more or less complete obstruction of the fossa. The swelling occasionally attains a very large size, displacing the septum, or projecting even from the nares. Hypertrophy of the anterior structures does not, as a rule, reach the extreme hardness often found in the posterior enlargements, nor is the peculiar raspberry appearance as frequently met with. Care should be taken not to confound true hypertrophy with collateral congestion or mere puffiness. It is only in exceptional cases that the floor of the nostrils and the whole of the inferior edge of the lower turbinated bone can be seen in a posterior rhinoscopic examination. Generally only the upper portion of its posterior end is visible, the lower half being concealed by the veil of the palate, and this anatomical fact furnishes an excellent guide in measuring the amount of hypertrophy. When, however, the posterior part of the lower turbinated body is hypertrophied, it appears in the mirror, rising above the velum, to a height varying with the amount of enlargement. It often projects backward over the palate into the naso-pharynx, and occasionally extends across the septum to the nostril of the opposite side. The inferior meatus may be alone occluded, or the whole naris may be occupied by the hypertrophic mass. The latter is sometimes freely movable, and may readily be mistaken for polypus. It may be uniformly smooth or irregularly lobulated, or it may be studded with little protuberances giving it the appearance of a raspberry. It varies in color from a dirty grayish or yellowish-gray color to a deep red or even purplish hue. In contour it is either rounded or oval; sometimes its upper border is irregular in outline, occasionally presenting a depression at its upper inner aspect.

The hypertrophy is nearly always bilateral and associated with a swollen condition of the tissue covering the middle turbinated bone and posterior half of the septum. In some cases I have been able to demonstrate its existence even on the superior turbinated bones. After the removal of the redundant tissues small nodular growths are occasionally seen in the middle meatus which represent localized hypertrophies or polypoid growths of that region. The hypertrophic turbinated tissues have sometimes a whitish, œdematous, almost hydatid appearance due to cystic degeneration of the mucous membrane. Almost always there is a corresponding hypertrophy of the tissue covering the septum, which bulges into the fossæ on either side and assists in the occlusion of the nostril. In this situation the hypertrophied tissue sometimes presents a depression corresponding to the convex enlargement of the turbinated bone. Small localized hypertrophies of the lateral surfaces of the septum are also observed, presenting the appearance of papillary growths. Hypertrophy of the upper posterior half of the septum is common in long-standing cases and causes a bulging on either side of the median line, which, with the central depression, presents sometimes a heart-shaped appearance. The blood-vessels over the septum are often enlarged and tortuous. In the majority of cases hypertrophy of the pharyngeal tonsil exists, either as a well-defined sessile tumor or as a mass of polypoid vegetations. This hypertrophy is at times so excessive as to fill the entire naso-pharynx, occluding the nares and Eustachian tubes, and pressing the velum downward and forward. The lips of the Eustachian tubes are generally enlarged, tumefied, and reddened, their orifices dilated and patulous. This gives the tube the appearance of an enlarged cervix uteri in a state of chronic hyperplastic inflammation. Occasionally a granular condition is noticed, due to swelling of the muciparous glands of the tube (tubal tonsil of Gerlach). They are sometimes occluded from pressure of the enlarged pharyngeal tonsil and hypertrophied turbinated bodies. Mucus collects in the orifices of the tubes, in the fossæ of Rosenmüller, on the pharyngeal vault, and in the posterior nares. Usually a thick, tenacious shred extends from the vault of the pharynx to the posterior border of the septum. All secretion must be removed before a satisfactory diagnosis can be made.

Adenoid growths appear as sessile or pedunculated vegetations of varying size, number, and consistence, scattered over the vault, posterior and lateral pharyngeal walls, and upper part of the septum. They are often massed together so as to form a tumor of considerable magnitude. When removed, they present the gross appearances of papillomata. Their diagnosis can be made with the mirror, or, in small children, by means of the finger introduced behind the velum. The sensation communicated to the finger is compared to that obtained by touching a bunch of worms. They bleed readily when touched, and, as a rule, discharge profusely. In all cases of deafness in children the naso-pharynx should be examined for these growths; if present, their ablation is imperative. If thoroughly removed, the deafness and nasal discharge rapidly, often immediately, disappear; and, if the case be not complicated with hypertrophic catarrh, no further treatment will be necessary.

We now come to a form or stage of nasal inflammation which for centuries has been the subject of much dispute, which is one of the most difficult of affections to deal with, and which in ancient times excluded its possessor from the privileges of the priesthood, and in more modern days has actually sufficed for divorce. It is the affection known under a host of names, such as dysodia, rhinostenose, coryza fœtida, fetid catarrh, dry catarrh, stinknase, punaisie,[*] rhinitis atrophica, rhinitis atrophica fœtida, etc.; but the most common of all appellations is perhaps the ancient one, ozæna, which, as implied in its Greek origin, signifies a stench from the nostrils. The term ozæna is an unfortunate one, for the condition is, properly speaking, not a disease *per se*, but a symptom of a number of pathological states. Thus it occurs in all ulcerative[†] diseases of the nasal mucous membrane, whether from syphilis, cancer, glanders, rhinoliths, and other foreign bodies (in which latter case it is almost invariably unilateral), phagedenic and other ulcers, and is the usual accompaniment of caries and necrosis of the intranasal bony framework. It also is occasionally present as a symptom or complication of nasal and postnasal growths, and may be symptomatic of simple or purulent inflammation of the accessary sinuses, and particularly of the antrum of Highmore. It may occur, too, as an accidental phenomenon from simple detention and decomposition of secretion in ordinary coryza, particularly in children, from imperfect removal of the secretion; or in adults and children, either from some imperfectly defined so-called "idiosyncratic" influence or from the presence of some vice of constitution, inherited or acquired. Occasionally a simple inodorous catarrh will become offensive at the menstrual epoch, losing its disagreeable odor during the decline of the ovarian disturbance; while any existing odor is very frequently aggravated at periods corresponding to those of the menstrual flow. Sometimes a condition resembling it is produced by snuff, various foods, and the habitual use of alcohol.

In the present article the term ozæna will not be used, and attention will be solely directed to that period of nasal inflammation which I have termed in my classification *rhinitis cirrhotica*, and which is used to denote a simple atrophic or cirrhotic condition of the mucous membrane of the nasal and accessary cavities, associated or not with corresponding changes in the bony framework, and which is usually if not always the representative of the third or last stage of hypertrophic nasal inflammation (*vide* section on Pathology).

It must not be understood that every case of hypertrophic catarrh, if left to itself, will terminate necessarily in atrophy. The latter process appears earlier in some cases than in others, the rate and time of its occurrence being probably dependent upon peculiarities of constitution, modes of life, and other conditions which influence the rate of progress of simple inflammation in general. In either or any event, it is usually the sequel of an hypertrophic condition—the legacy of a neglected or, what amounts to the same thing, a badly treated catarrh.

The existence of syphilis, or other diathetic conditions (see Pathology), undoubtedly predisposes to the atrophic process, and I am of the opinion that the constant and habitual use of alcohol is a prolific source of the new formation of connective tissue, just as it leads to similar changes in other organs, notably the liver and kidney.

The two most prominent symptoms of ozæna are the horrible odor and the special tendency to crust-formation. The crusts vary in color from a dirty brownish-gray or greenish-yellow to a pronounced blackish or coal-black hue. They exhibit also varying degrees of consistency, from soft, easily friable, to tough, leathery masses, and sometimes acquire a stony hardness which may lead to their confusion with dense foreign bodies. Uniform, or distinctly laminated in structure, they adhere with great tenacity to the mucous membrane, from which they are separated at intervals varying from two or three days to several weeks, as casts of the regions which they occupy. Occasionally the posterior nares become completely occluded, and the two obstructing crusts become connected by a band over the posterior edge of the vomer, so that when detachment takes place the expectorated crust presents an appearance not unlike that of a pair of eye-glasses.

They occur in all portions of the nose and nasal pharynx, and their expulsion is often attended with great difficulty. They are sometimes detached during sleep, when they may give rise to symptoms of sudden suffocation from their presence at the entrance of the laryngeal vestibule. Their separation is effected by the accumulation beneath them of a fetid muco-purulent secretion. This exudes from the under-surface of the crust, and bathes its surface with a thick discharge, in which the hardened mass is partially macerated and expelled, leaving an abraded, bleeding surface at the points of adhesion. The stench is generally intensified during the detachment of the crusts.

This tendency to inspissation of the discharge and the formation of crusts is, in a great measure, due to abnormal increase in the capacity of the nasal chambers, but it is doubtless also, to some extent, encouraged by the atrophy of the erectile and other sensitive tissues, and the consequent diminution in the reflex excitability of the nasal apparatus.

The amount of discharge varies greatly in different cases. At times it is so profuse that it necessitates the constant use of the handkerchief, while at others it is only trifling in amount. This has led some writers to describe two varieties of the disease, a moist and a dry atrophy.

The destruction of function which atrophy of the intranasal structure involves will naturally vary according to the region principally involved by the disease. The senses of smell and taste are usually impaired, or may be entirely destroyed.

Rhinoscopic Appearances.—The external nose is either normal in appearance or presents a variety of unnatural positions. The depressed, flat, and saddle-shaped nose which is characteristic of disappearance of the cartilaginous septum is rarely met with in simple atrophic rhinitis. The changes in the external nose will depend upon the extent to which the destructive process has advanced within the nostril. The abrogation of the respiratory function of the nostrils leads to impairment of the motions of the alæ nasi, and quite often the apex of the nose is tilted upward, so that the anterior nares look more or les directly forward. This elevation of the tip of the nose is also met with in contraction of the posterior parts of the nostril, and in adenoid growths of the nasal pharynx.

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[*] The term usually applied by the French. It is remarkable that in the Ayur Veda there is an affection described under the name *pinasa*, which is represented as occurring in an acute and chronic form, and which possibly is the disease in question.

[†] The ancients used the terms ozæna and ulcer of the nostrils as synonymous.

The mucous membrane of the dilated nostril, after the removal of the crusts, is thin and smooth, and of a pale reddish or dirty gray hue. Ulceration is not met with. According to my experience, in simple atrophy the atrophic process is most marked in the respiratory region, the lower turbinated bone being, in many instances, reduced to a mere rudiment, allowing in some cases a perfect view of the posterior nasal region. The middle turbinated structures are either atrophied or, as is often the case, simply hypertrophied, and hang in the dilated meatus like polypi. When extensive atrophy exists the posterior upper wall of the nostril (pars olfactoria) can be seen presenting the appearance of a more or less lobulated growth. In rare cases the pars nasalis and the upper turbinated bones can be distinctly seen. The changes described above are usually found in both nostrils, but cases are occasionally met with in which the atrophic process is limited to a single nostril, and this apparently independently of pre-existing or concomitant aural disease.

PATHOLOGY AND PATHOLOGICAL ANATOMY.—The following account of the pathology and pathological anatomy of intranasal inflammation is based mainly on an anatomical study, now extending over a period of over seven years, of a large number of inflammatory growths removed from different portions of the nasal chambers and at all stages of the catarrhal process. These observations were first published in the *Medical News* for October 4, 1884.*

I. The changes found in common catarrhal inflammation of the nasal passages are pathologically separable into three distinct groups, corresponding to the three clinical stages of the disease, viz., the simple inflammatory, the hypertrophic, and the atrophic.

The gross anatomical appearances of the first stage consist essentially in localized or diffuse injection, with moderate swelling of the tissues.

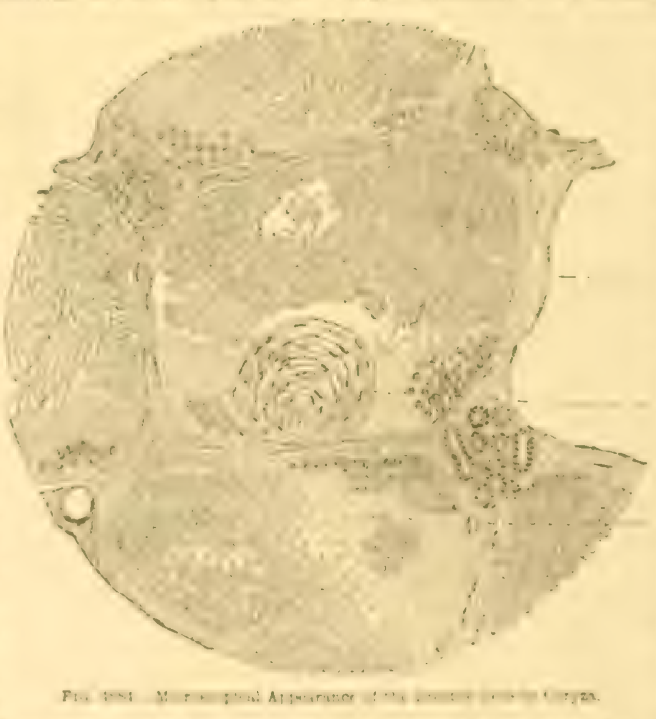

FIG. 1251.—Microscopical Appearance of the Erectile Tissue in Coryza.

There is very little, if any, swelling of the mucous membrane proper, the main condition being repeated engorgement of the erectile bodies. Portions of the mucous and underlying tissues removed with the snare bleed freely, are soft to the touch, can generally be flattened out with the finger, and, when thrown into alcohol, sink slowly to the bottom of the vessel. They are uniformly smooth in contour, and present, when first removed, a dark purplish and mottled look on the upper surface, while on the under aspect the peculiar spongy appearance of the honeycomb and dilated erectile body can be distinctly made out. Under the microscope the appearance which immediately strikes the eye is the enormously dilated and engorged condition of the erectile spaces and the extreme tenuity of their walls. The latter are often reduced to the merest shred, resembling the meshes of a delicate web. Occasionally, large, irregular spaces are observed, which doubtless result from rupture, either before or during the compression produced by the snare. In some cases small hemorrhages are discoverable in the submucous tissue. I have not met with any notable changes in the mucous membrane. The epithelial layer is usually intact, and beyond perhaps a slight amount of cellular infiltration of the submucous tissues, there is nothing to call for special remark. An excellent idea of the condition of the erectile cells in the first stage may be derived from inspection of the accompanying drawing, in which we have, too, the probable microscopical picture of coryza.* In the case from which the section was taken, the nasal passages presented the appearances commonly observed in the condition known as coryza, and in the permanent puffy condition found in more chronic inflammation, the most noticeable being intense engorgement of the cavernous tissue, especially well marked over the lower half of the middle and posterior portion of the inferior turbinated body. Upon cutting into the engorged bodies with a snare, the blood, which flowed freely, could be squeezed from them as water from a sponge. The mucous membrane of the maxillary sinuses was not in the slightest degree touched, and presented simply a more or less cyanotic appearance.

Under the microscope the condition which at once attracts the eye is the enormous dilatation of the erectile spaces and the extreme tenuity of the intercellular walls. Here and there rupture of the latter had occurred from the enormous blood pressure, and two or more spaces in this way communicated. Along the inner walls of the dilated spaces were seen congregations of lymphoid corpuscles and in some of them collections of fibrinous exudation.

The mucous membrane proper presented no noticeable pathological change. The epithelial layer was intact. At some places it seemed slightly thicker than at others, but beyond a moderate amount of cellular infiltration of the tissues beneath the basement membrane, there was nothing in the mucous layers to call for special remark.

Jutting out from and attached to the wall of the central space (n, the diagram) was a well-formed parietal thrombus, to which I would like to call particular attention.

Here, too, is illustrated the minute anatomy of the puffy condition or state of permanent dilatation of the erectile spaces which characterizes the second period of the simple inflammatory stage before hypertrophic changes have developed, and to which I have called attention elsewhere (see Classification).

Of great interest, too, is the formation of the parietal thrombus as illustrative of a mode of obliteration of the erectile spaces hereinafter alluded to.

In the second, or hypertrophic, stage, the gross appearances vary considerably. The growths, when removed, are either round or oval in contour, uniformly smooth or irregularly lobulated, or covered with little protuberances, giving them the appearance of a raspberry. Frequently, when the loop of the snare is disengaged from the hypertrophied tissue, a small shred or stem projects from the under surface of the latter, which, together with the smooth upper surface of the growth and its rounded, folded inward edges, presents a striking resemblance to a mushroom. The hypertrophies vary in color, from a dirty grayish or yellowish-gray, to a red, and even purplish hue. The color and density of the hypertrophy vary with its age. The older the growth, the paler the color and the harder the consistency.

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* The accompanying drawing [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Hospital, [illegible] [illegible] [illegible] [illegible].

* These observations were first brought before the American Laryngological Association in June, 1886, in a paper entitled A Contribution to the Pathological Histology of Acute and Chronic Coryza. See Transactions; and also New York Medical Journal for August 28, 1886.

Cross-section with a knife discloses often a peculiar *nutmeg appearance*, due to the interlacing fibrous bands and the dark-brownish aspect of the blood in the erectile spaces. In other cases this nutmeg appearance is not well marked, the whole tissue being converted into a dense, fibrous mass. These masses are incompressible, and sink immediately when thrown into the preserving fluid. They are sometimes covered with little granular or papillary projections.

The microscopical appearances vary. In all, the most remarkable is the conversion of the walls of the erectile spaces into dense fibrous bands, which, in contracting, obliterate more or less completely the erectile cells.[*] These latter present numerous irregularities in outline, and, in those places where the fibrous change is most marked, contain very little, or are altogether destitute of, blood. This fibrous process invades the submucous tissues, and converts them, too, into a fibrous mass in which their glandular elements disappear. The latter are apparently destroyed or obliterated, not only as the mechanical result of the contraction of the new-formed tissue, but also by cellular infiltration of the glandules themselves. The latter is of two kinds, an intra- and peri-acinal.

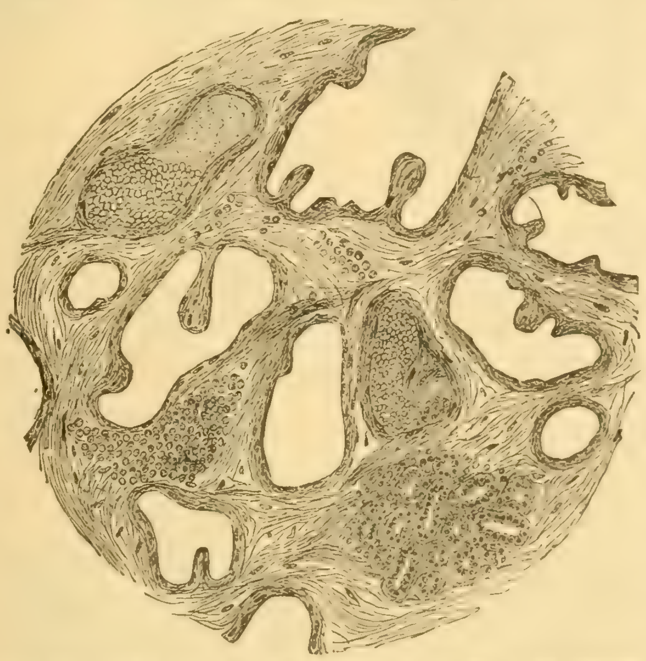

FIG. 4885.—Buds or Bulbous Processes projecting from the Walls of the Cavernous Sinuses.

When the fibrous process is confined to the deeper layers, the epithelium is usually intact. When, however, the structures immediately under the basement membrane are invaded by the round-cell infiltration, the epithelial layer is notably thickened, often in an irregular manner. This thickening is most marked in the undulations of the free surface. Occasionally the epithelial proliferation assumes the form of distinct filamentous papillary growths, which are beautifully shown under the microscope.

In some places the epithelial cells are filled with a granular detritus, or are altogether wanting. The latter occurs when the fibrous process encroaches on the superficial layers and obliterates their blood supply. When this occurs, the epithelium may be entirely gone over a considerable extent of surface, nothing being left but the basement membrane. When all the layers are involved in the shrinking of the new-formed tissue, the surface of the growth is often thrown into small, pear-shaped projections or knobs, which consist entirely of fibrous tissue. I am inclined to believe that these knobs may subsequently become detached, and that this process of detachment may be one step in the future atrophy of the membrane. For, if the histories of certain cases of atrophic rhinitis be carefully taken, it will appear that, from time to time, there are found in the discharge from the nose, during the hypertrophic stage, small nodular masses, which are described by the patients as "little pieces of flesh." They will affirm, furthermore, that, when this has occurred, the nostrils are perceptibly freer, and, encouraged by this false hope, which they take as an evidence of return to the healthy condition, they neglect treatment and allow the disease to go on to the atrophic stage. I have not met with any mention of this clinical fact in the writings of others, and am inclined to the opinion that the "pieces of flesh" are none other than these polypoid knobs of fibrous or papillomatous tissue, and that their expulsion may be regarded as an index of approaching tissue destruction.

Before leaving this brief consideration of the hypertrophic stage, I wish to call attention to an appearance which I have twice met with, viz., the obliteration of the lumen of the erectile spaces by masses of round cells which resemble the white corpuscular elements of the blood.

I also wish to call attention to certain buds or bulbous processes which in the hypertrophic stage are occasionally found jutting out from the walls of the cavernous sinuses, and which are made up of outgrowths from the newly formed connective tissue. These appearances were first pointed out to me by my friend Professor Councilman, of the Johns Hopkins University, who had taken one of my sections for examination.

Projecting inward, they form bulbous processes or septa of varying thickness, which sometimes interlace, sometimes form bands which connect one portion of the sinus-wall with another, thus constituting another factor in the division and obliteration of the cavernous spaces. Care should be taken not to confound them with the remains of a thinned and ruptured intercellular wall; in the latter case a similar projection will usually be found at a point diametrically opposite to that occupied by the projecting band.

We have, then, four modes of obliteration of the erectile spaces in nasal inflammation:

1. By the contraction of the newly formed intercellular fibrous bands.
2. By obliteration of their lumen by masses of round cells which resemble the white corpuscular elements of the blood.
3. By the formation of thrombi in certain cases.
4. By the process of septa-formation.

The transition of the first stage into the hypertrophic does not seem to me to depend necessarily upon the presence of constitutional disease, or vice of constitution, inherited or acquired. While it is true that certain diathetic diseases predispose, other things being equal, to the development of this fibrous tissue in excess, the same takes place in the perfectly healthy, and in those who are free from the slightest trace of constitutional taint. In the hypertrophic tonsillar bodies which I have removed from syphilitic patients the fibrous tissue was notably excessively developed, and that this disease predisposes to the subsequent atrophy of the tissue, I think there can be no doubt. It is, indeed, doubtless true that certain diathetic conditions, and especially the inherited form of syphilis, as well as certain imperfectly understood personal peculiarities, exert an important influence in the determination of the atrophic stage of rhinitis; but there is a form which, in the present state of our knowledge, is indicative of no particular dyscrasia, traceable to no particular vice of constitution, occurring in the healthy as well as in the badly nourished and cachectic, the clinical and histological history of which contains nothing to differentiate it from the atrophic stage of a simple catarrhal inflammation.

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[*] This connective tissue formation has also been studied by Seiler (Diseases of the Throat, Philadelphia, 1883, p. 197) and Bosworth (New York Medical Record, June 10, 1882). Seiler found the epithelium intact, although some fatty degeneration of the cells had taken place. In Bosworth's sections the epithelial layer was greatly thickened. The myxomatous change which takes place in the fibrous tissue, and which is mentioned by Seiler, I have also observed.

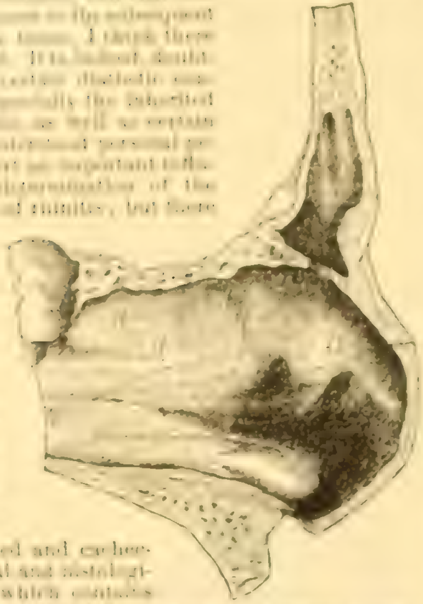

Fig. 4886.—Enormous Hypertrophy of the Mucous Membrane and Underlying Structures of the Septum Narium. (Drawn by A. C. [illegible].)

II. Is rhinitis ever *ab initio* atrophic? In the absence of direct histological proof of such an occurrence; in consideration of the rapidity with which, in some cases, the hypertrophic variety passes into the atrophic; in view of the many obvious difficulties in the way of certain historical data in its favor, and in the light of anatomical investigation, I think that, for the present, at least, this question must be answered in the negative. The strongest argument in favor of the independent origin of the atrophic form is the alleged occurrence of ozena in the newly born—that is to say, atrophic changes show themselves at a period too soon after birth to warrant the assumption of a pre-existing chronic catarrhal inflammation. It seems to me that this objection is sufficiently answered by the by no means violent assumption of the previous existence of an intrauterine catarrh.*

That atrophic rhinitis always appears as the sequel of a pre-existing catarrhal inflammation is rendered highly probable from a number of clinical and pathological facts. If the clinical history is accurately taken, it will point to a pre-existing catarrhal process. As has been indicated above, the rapidity with which the hypertrophic passes into the atrophic form of rhinitis is proportionate, in all probability, to the presence of some constitutional taint, such as the congenital or acquired form of syphilis. The early appearance of atrophy in some cases is dependent, doubtless, too, upon certain modes of life and other conditions which influence the rate of progress in simple nasal inflammation in general. I have seen it also occur with rapidity after the profound impression made upon the nutrition of the parts as the result of acute systemic disease. If the patient is not under intelligent special observation from the outset, it may be difficult to establish with certainty the chronological relationship of the two stages; but so far as my observation goes, I have never been able to satisfy myself of the independent origin of the atrophic form.

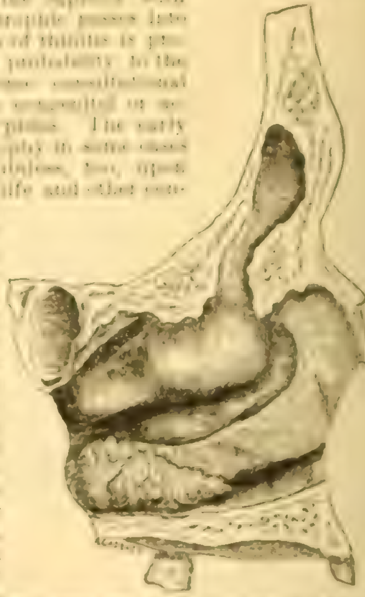

Fig. 4887.—The Hypertrophic Stage of Rhinitis Chronica.

In this connection it is worthy to note that the transition of hypertrophy into atrophy does not necessarily imply the existence of ozena. I now and then see cases in which the most widespread atrophy has occurred, and in which the capacity of the nasal chambers is greatly increased, in which no odor can be detected; and I have removed portions of membrane from the nose which showed under the microscope marked atrophic changes, in which no symptoms of ozena, strictly speaking, were present. How is the fact to be explained that in some cases in which extensive atrophy has occurred there is an absence of the characteristic odor of ozena, while in others (exclusive, of course, of pre-existing disease of the accessory sinuses) in which the destruction is less extensive, there is pronounced fetor? It is insufficient here to urge the operation of adventitious influences or the theory of simple decomposition. Does not the presence of the peculiar odor depend rather upon agencies operating within the tissues than upon those which approach from without? In other words, is not the atrophy that results from simple inflammation less liable, other things being equal, to give rise to the characteristic stench than that which depends upon constitutional causes?*

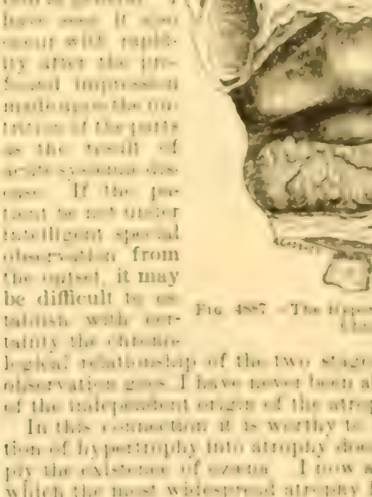

Fig. 4888.—Atrophic Rhinitis.

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* In this case the [illegible]

* I have shown elsewhere (Congenital Syphilis of the Throat, [illegible]) that the [illegible] form of congenital syphilis [illegible] more frequently among [illegible], a fact which may perhaps explain the frequent occurrence of ozena among young girls at or about the age of puberty.

The pathological history of "ozæna" is, moreover, that of the conversion of hypertrophic changes into those of an atrophic form. In the rhinoscopic image, in the microscopic section, the processes of hypertrophy and atrophy are found side by side. More than that; the atrophic changes are more pronounced in situations in which the catarrhal inflammation originally developed. Thus, for example, if the disease originate as a catarrh of the maxillary sinus, the atrophy is more pronounced in the latter situation, the nasal mucous membrane proper presenting evidences of simple or hypertrophic catarrhal inflammation. If, on the other hand, the disease commence in the nasal fossæ, the morbid condition of the sinus, if such exist, is that of simple or hypertrophic inflammation. Finally, as the hypertrophic variety almost invariably commences in the respiratory portion of the nostril, so in the atrophic form, the region of the inferior meatus, the classical seat of atrophy, is the first to be destroyed.

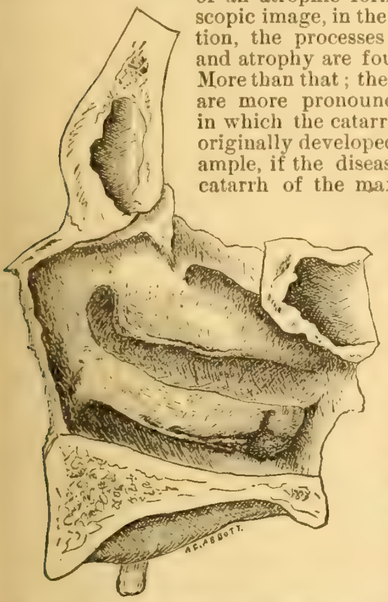

FIG. 4889.—Transition Stage from Hypertrophic to Atrophic Rhinitis.

Weighty evidence in support of the position that atrophy is always preceded by catarrhal inflammation, is furnished by the microscope. Here the processes are either found side by side in the section, or portions of the membrane show signs of atrophy, while in others, where the process is less advanced, hypertrophic changes are discovered.

I have never had the opportunity of a thorough post-mortem examination of a case of ozæna, but I have found the essential changes described by others—the process of contraction, destruction of glandulæ, etc., in the hypertrophic membrane removed with the snare—a condition of *turbinated cirrhosis*, so to speak, so that I am forced to regard this atrophy of the membrane, which may with propriety be called *rhinitis cirrhotica*, as the sequel of a pre-existing hypertrophic condition. At no stage of the catarrhal or atrophic process have I ever met with ulceration.

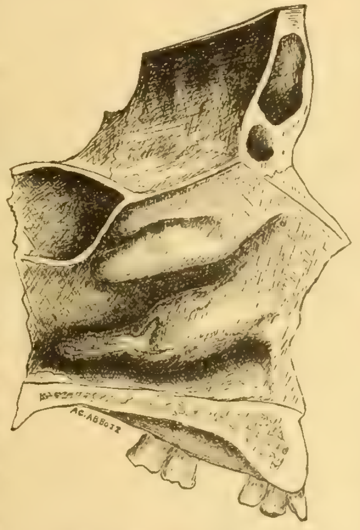

FIG. 4890.—Atrophic Rhinitis (Syphilitic). The characteristic cicatrices are seen on the posterior end of the inferior turbinated bone.

An opportunity is rarely offered for the histological study of pure uncomplicated atrophy of the nasal mucous membrane. Such chances belong to the accidental discoveries of the post-mortem table, and it is therefore only in a few isolated cases that its pathological histology has been recorded. Among these the most carefully studied are those of Eugen Fränkel[24] and Hermann Krause.[25]

When the nasal cavities are exposed, they are found filled with a dirty, discolored, foul-smelling mucus and crusts. Upon removing these, the atrophied mucous membrane is seen to be of a pale ashy-gray or dirty brownish color, its surface either smooth or glazed, or thrown into folds, giving it more the appearance of a serous than a mucous membrane (Zuckerkandl[26]). Dense in consistence, it can sometimes be stripped with ease from the underlying periosteum. Associated with this thinning of the mucous membrane is always more or less corresponding atrophy of the bony framework, and especially of the inferior and middle turbinated bones. Zuckerkandl, who has studied the different phases of atrophy of the turbinated bones in morbid specimens, finds that in the mildest grades of atrophy there is simply thinning, with rupture of continuity, or occasionally perforation of the bone. Later on, the free convex edge of the bone becomes straight, or even concave, and, as the process goes on, it is reduced to a mere ridge along the wall of the nostril. These changes are more pronounced in the respiratory region, but not infrequently invade the olfactory area.

The histological picture is simply that of a gradual atrophy or wasting away of the different layers of the mucous membrane, and the conversion of their individual elements into fibrous connective tissue, a purely cirrhotic or sclerotic process. The free surface of the mucosa is either completely deprived of its epithelium, or covered with cells of varying size and contour—round, polygonal, or spindle-shaped—with cloudy contents and illy-defined nuclei. Here and there it is covered with a fine detritus, which probably represents the remains of the epithelial cells. Fränkel found embedded, in a mass of round and spindle cells a number of small oval or rounded nodules, of a transparent, homogeneous appearance, which were found, upon examination with the higher powers of the microscope, to consist of broken-down cells and nuclei, and which were more or less completely isolated from the tissues in their vicinity (as a rule, in the neighborhood of the free surface). Fränkel regards these circumscribed nodules as the representatives of a retrograde metamorphosis of small cells and nuclei—a process presenting a certain resemblance to the infiltration of cells and nuclei of the subepithelial layer of the vocal cords in certain forms of phthisis.

The subepithelial layers are either crowded with round and spindle cells, represented by a ground substance (stroma) of fibrous tissue, or are converted into a dense structure composed of bands of fibrous connective tissue running parallel with the free surface of the membrane, and enclosing in its substance round and spindle cells, sometimes massed together, the long diameters of the latter being also parallel with the free surface. Here and there, either lying between the meshes of the fibrous tissues, or within the substance of the spindle cells themselves (Fränkel), pigment masses are found which consist of an amorphous granular matter, and which are more often met with in the upper layers of the membrane, and which disappear as the periosteum is approached. In the cases of Krause, the round and spindle cells either contained a cloudy, granular protoplasm, or had lost their contour and become converted into a fatty detritus. Krause, moreover, found everywhere, interspersed among the different layers, masses of fat granules, either assuming the form of spindle cells or arranged in rows alongside of each other. In addition to these, which should not be confounded with pigment, groups of fat-globules were discovered, which presented a light, grayish-yellow coloration, and which, together with the fatty degeneration of the cellular infiltration, are regarded by Krause as the cause of the odor in the disease (*vide infra*).

The glands either show no remarkable changes in structure and number, being simply surrounded by a round-cell infiltration in different grades of degeneration of their stroma may be so encroached on by the newly formed connective tissue as to cause their complete disappearance. This result results not only from the compression of the acini, but also from the interference with their vascular supply through the diminution in the calibre of the blood-vessels of the affected area. The changes which bring about this contraction consist in thickening of the adventitia, with corresponding narrowing of the lumen of the vessel.

In Fränkel's case the lumen of the smaller vessels of the olfactory region, and especially the arteries, was greatly diminished or completely obliterated by inflammatory changes in the tunica intima (endarteritis obliterans), while in the respiratory passages these changes in the lumina of the smaller vessels were not present.

So far the microscope has failed to reveal any noticeable change in the nerve elements.

The changes described above are much less pronounced in some places than in others. Here and there the microscopical appearances are rather those of a simple catarrhal inflammation than of an atrophic condition. These are more marked in the respiratory than in the olfactory region, and may be associated with similar processes in the accessory sinuses. The changes in the latter represent an earlier or a later stage of the inflammatory process according as the sinuses were originally the starting-point of the disease or were invaded secondarily by the inflammatory process. Thus the mucous membrane of the nasal fossa may be atrophied, while that of the sinuses shows evidence of an acute inflammation or a chronic hyperplastic process.

The changes in the periosteum and bony framework consist essentially in the gradual atrophy of the latter. The walls of the Haversian canals are gnawed away in an irregular manner, their lumen is filled with osteoblasts containing a varying number of nuclei, and in some places the space between the individual canals is so narrowed that nothing but a thin remnant of the bone is to be seen (Krause). Division of the nuclei of the bone corpuscles has been also observed (rarefying osteitis).

It is doubtful whether true ulceration ever occurs as a lesion of simple atrophy. Occasionally abrasions of the mucous membrane are seen which result from accidental causes, such as the use of the finger in the detachment of crusts, or from the separation of the latter when closely adherent to the surface; but neither abrasion nor true ulceration can be, in my experience, included in the pathological picture of the disease.

Against the theory that the atrophic process represents the later stages of hyperplastic or hypertrophic catarrh, Dr. Bosworth,[illegible] of New York, basing his view on personal observation, believes that the atrophy is "not due to connective-tissue hypertrophy encroaching on the glandular structures of the membrane, but rather to the transformation of epithelial structures into inflammatory corpuscles, together with an active epithelial desquamation from the surface of the membrane, and the lining of the acini." He believes also that the atrophy of the turbinated bones is due to pressure exercised on them "by the drying and contracting of the inspissated mucus," which process he compares to the action of a film of collodion. The latter speculation is scarcely conceivable, and in regard to the former, while it is doubtless true that round-cell and perhaps glandular infiltrations, as shown above, play a certain rôle in the atrophy of the glandulæ, there is abundant histological evidence to show that they are not constant or essential factors; while the histological observations of others and myself place the facts of connective deposit and contraction of newly formed connective tissue beyond the reach of reasonable controversy.

The horrible stench, which suggested the term ozæna, is one of the distinctive objective features of the atrophic stage. It has been compared by the French to the smell of crushed bedbugs, but even this is not sufficiently descriptive. It is penetrating, nauseous, disgusting in its sickening odor and sweetish. Its cause or origin has given rise to much discussion and speculation. To account for it, some have assumed the existence of a ferment or micro-organism, either developed in the nasal secretion or derived from the surrounding atmosphere; and that this ferment can be transferred from individual to individual is thought to be probable from the occurrence of ozæna in several members of the same family, and its disposition in certain countries, as in Galicia, Poland, and Russia. This hypothesis has, however, been overthrown by the failure to find such a ferment, and by the negative results of direct inoculation with the secretion of the atrophic nasal membrane.

According to others, ozæna, or atrophic rhinitis, originates as a chronic purulent inflammation of the accessory sinuses, especially the ethmoidal and sphenoidal, the decomposition of the secretion in these cavities furnishing the explanation of the peculiar odor. This theory, which was originally advanced by Drake,[illegible] copied by Vieusseux,[illegible] and Rouge,[illegible] and which has been resurrected in recent days by Michel,[illegible] is at variance not only with the clinical but also with the anatomical facts of the case, as demonstrated by post-mortem examinations. There is abundant clinical and anatomical evidence to show that the sinuses are, as a rule, only secondarily affected, and that a simple purulent inflammation is of itself insufficient to produce the characteristic odor of the disease.

From the stunted or atrophied condition of the turbinated bones, and especially the inferior, which usually accompanies the affection, and the consequent increase in capacity of the nasal chambers it has been thought by some that congenital atrophy of the turbinated bones, and particularly the inferior, is the essential feature in atrophic catarrh. This speculation, which has been especially insisted upon by Zaufal,[illegible] rests, however, upon the assumption of facts which in all probability do not exist, for both clinical observation and pathological anatomy alike demonstrate the fact that atrophy of these structures is invariably secondary—always the result of preexisting disease of the turbinated tissues. If congenital atrophy occur at all, it must be reckoned among the rarest of pathological curiosities; for investigations purposely directed with reference to this question have failed to discover its existence.* There is, moreover, no case on record which may be looked upon as an unequivocal example of congenital atrophy. That abnormal widening of the nasal cavities is of itself insufficient to account for the stench is shown by the fact that the odor is not infrequently altogether absent in cases in which atrophy and destruction of the turbinated tissues, resulting in a most widely opened cavity, has taken place. While it is unquestionably true that abnormal widening of the nasal passages favors and predisposes to the development of putrefactive changes within the nose, it is at the same time highly probable that it alone is not enough to account for the peculiar fetor of the disease. To explain the latter it is necessary to assume the existence of some other influence, or some alteration in the chemistry of the nasal secretions brought about either by the atrophic changes in the nasal tissues, or from some constitutional or systemic cause. Exactly what such alteration consists in, is as yet unknown. Whether it be produced by atrophy and disappearance of the glandular elements (Bowman's glands), or by the evolution of fatty acids from the disintegration of fat globules and leucocytes (Krause), are questions which have received as yet no definite solution. The existence of the former seems hardly sufficient to account for the fetor, while the presence of fat is probably accidental, and has been demonstrated microscopically only in the cases of Krause.

Putrefaction implies the presence of a micro-organism, and hence it is not surprising that the dominant pathology of the present day should inspire a vigorous [illegible] search for a possible special microbe. Many observers have seized upon the opportunity presented, among whom may be mentioned Löwenberg[illegible] and Eug. Fraenkel.[illegible] The first-named author claims to have discovered a special diplococcus, which he believes to be the essential cause of the disease. But, unfortunately, when the evidence on the subject is thoroughly sifted, there is only one conclusion possible, viz., that, in the present state of our knowledge the existence of a characteristic microbe, capable of producing the disease, has not been demonstrated, and that the investigation of the matter has as yet yielded no practical results. The constant exposure of the already fetid and decomposing nasal exudation to every vitiation of the atmosphere,* is of itself sufficient to render the problem an exceedingly complex one, and it is, therefore, very doubtful whether the discovery of a special microbe for atrophic rhinitis will be an event of the immediate future.

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* In 378 [illegible]

In this country, the changes in the common catarrhal affections of the nose are most marked in the area covered by erectile tissue, and are more pronounced in the lower or respiratory region, in the bony nostril than in the vestibule, and occur in the posterior more frequently than the anterior portions of the nasal fossæ.

These changes have their starting-point in one or more of three different structures, the erectile tissue, the mucous membrane, and, perhaps, the periosteum. The erectile tissue is primarily involved, probably, in those cases in which catarrhal conditions are met with as the result of reflected irritation (doubtless through vasomotor influences operating, in the first instance, through the constant or repeated erection of that tissue, with subsequent development of trophic disturbances), and it is conceivable that the same result may be brought about through obstruction or other derangements in the local or systemic circulation; in fine, from any cause that does not act as a direct irritant to the mucous membrane. Even in the latter case the local irritant may, and does in some cases, bring about a similar result through reflex action. A more or less constant dilatation of the erectile cells is thus brought about, which, if kept up, will eventuate, sooner or later, in a paralytic or subparalytic state of the resilient and contractile elements of the intercellular connective-tissue walls.

In another class of cases the process starts from the superficial layers of the mucous membrane, through the irritation produced by foreign substances, the lesions of acute and chronic constitutional or systemic diseases, either through direct infection or through vitiation of the general circulation, and the consequent changes in the nutrition of the mucous membranes. Even in this class there is always more or less secondary erection of the cavernous tissue.

There is still a third class, in which it is probable that the changes in the erectile tissue are secondary to hyperplastic conditions of the perichondrium, as, for example, in the hard, dense hypertrophies met with in syphilitic subjects.

Wherever originating, the erectile bodies become sooner or later involved, and the subsequent changes which they undergo constitute the characteristic feature of acute and chronic nasal inflammation. This is the distinguishing mark between it and other inflammatory conditions of the mucous membrane of the respiratory tract, and it furnishes the rational guide to the management of these affections. I wish to emphasize this fact, for it marks an era in nasal therapeutics. That it is not fully appreciated, is evident from the fact that authority often sanctions the use of methods, the inevitable tendency of which is to bring about results directly opposite to those they are intended to accomplish.

DIAGNOSIS.—The diagnosis of the different stages of chronic nasal inflammation is generally sufficiently easy from the history and rhinoscopic appearances. These have been given above, and it now only remains to point out a few difficulties which may present themselves to the beginner, or even the experienced practitioner. Before doing so it may be well to give some practical hints concerning the early recognition of intranasal inflammation.

In the natural state the lumen of the nostril, or that space which exists between the turbinated bodies and the septum, is indicated by a slit, narrow and pointed above, and broader and more triangular below, which may be roughly compared to the slit in the sounding-board of a violin. When the turbinated tissues are made to contract artificially, obliteration of this slit occurs, the middle and inferior meatuses are represented by a broader, more pyramidal passage, and the middle and deeper portions of the nostrils come into view. The opening of the posterior nares into the retronasal cavity is then seen as a dark, clearly cut, perpendicular line. In some persons, especially in those whose nasal chambers are naturally capacious, this linear opening may be seen without artificial contraction of the turbinated bodies.

The position of the turbinated bodies also varies within certain limits in the normal condition. When the inferior turbinated bone is "depressed," its anterior end appears as a rounded, or, in some instances, bluntly pointed protuberance jutting out from the external anterior wall of the nostril, and closely in contact with the floor of the inferior meatus, from which it seemingly springs. When the bone is "elevated" there is a distinct, sometimes very broad, space between its inferior border and the nasal floor, the curve and dip of its anterior extremity is generally well defined, so that a *comma-shaped space* is left between it and the external wall. The inferior surface of the bone is not visible except in cases in which the long axis of the bone is directed upward and forward.* In some families, the inferior turbinated bone of one side is unusually developed without giving rise to serious inconvenience,† a fact which it is well to bear in mind in coming to a conclusion in diagnosis.

The rounded, bulging, middle-turbinated bone occupies the upper and outer portion of the anterior rhinoscopic picture. In the anterior portion of the nostril the space between it and the inferior varies greatly within the limits of health. Usually it presents a more or less pear-, or inverted comma-shaped appearance, with or without a comma-shaped space between it and the outer nasal wall.

It is only in very exceptional cases that the superior bone can be seen.

In the posterior rhinoscopic image the floor of the nostril is not visible in health, being hidden by the bulge of the palatal muscles, and the inferior edge of the lower turbinated bone can be seen only in exceptional cases of the "elevated" form. Generally only the upper portion of its posterior extremity is visible. The posterior border of the septum is almost invariably straight, but just anterior to it, and within the nostril, there is a slight bulging or cushion which represents the cavernous body located there.

The middle turbinated body generally projects inward as a pear-shaped protuberance, while the superior is either scarcely visible, or appears as a rudimentary-looking tubercle or projection.

Only a small portion of the inferior meatus is visible as a small, dark, and three-cornered space. That portion of the middle meatus which is included between the turbinated bones is seen in the mirror as either a half-moon or an imperfectly defined S-shaped slit. The irregular spaces between the bones are continuous with the space common to the three meatuses, and which appears as a dark chamber in the rhinoscopic image.

The color of the mucous membrane in different individuals and in the same individual, at different periods, varies within the limits of perfect health. It may be said, in general, that it is of a pale reddish hue, more pronounced in the area covered by erectile tissue. In the posterior rhinoscopic picture the color of the membrane appears of a darker hue, the parts being thrown more or less into shadow.

The mucous membrane is closely adherent to the an-lower portion of the septum and walls of the vestibule, while over the posterior part of the septum and turbinated bodies it is loosely and separated from the periosteum by the erectile body, which becomes a thin layer as the anterior extremity of the bone is reached.

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* A German investigator (Thost) claims to have found the so-called coccus of pneumonia in the nasal secretion of ozæna patients.

* In a patient suffering from mental [illegible], I observed the inferior turbinated bone so elevated that it occupied the position usually occupied by the middle, and its obliquity was such that more than half of its inferior surface was distinctly visible.

† I have observed this condition twice.

In the anterior portions of the nostril, therefore, the turbinated bodies are more compact and closely adherent than in the posterior segments of the nasal chamber.

I have dwelt upon the above anatomical considerations because I have found them invaluable guides to diagnosis. In anterior rhinoscopy the amount of swelling may be very conveniently measured by the changes in breadth and direction of the S-shaped slit and the degree of obliteration of the turbinated-septal space; while the amount of posterior hypertrophy is most accurately determined by the anatomical facts detailed above. The amount of swelling on the septum may also be determined in a similar manner.

The amount of swelling or hypertrophy, and the implication of the bone in the process, may furthermore be measured by the hard and incompressible, or the soft and yielding character communicated to the finger by the probe; while hypertrophy may be differentiated from mere puffiness by the ease with which the erectile bodies may be emptied or compressed by mechanical causes or artificial contraction. In the latter case the rapidity of contraction is often a measure of the amount of mere puffiness. In using cocaine, for example, if the swelling be due to mere puffiness or to transitory engorgement, it subsides very rapidly, almost instantly; while if hypertrophy exists the tissues collapse much more slowly and less completely.

In making the diagnosis of incipient rhinitis it should be borne in mind that the disease not infrequently has its starting point in the erectile bodies, and occasionally in the periosteum. In such cases the first evidence of its existence is a more or less engorged state of the area occupied by cavernous tissue. A stimulus, too, which in the normal state would exert little or no impression, is usually sufficient to provoke more or less erection of this tissue with, it may be, the evocation of reflex phenomena. In all cases the cavernous structure becomes sooner or later involved. Abnormal irritability of the area covered by this tissue, and slight puffiness of the same, are, therefore, invaluable guides in the early recognition of chronic intranasal inflammation. It should be borne in mind, at the same time, that this condition of the erectile bodies is not always the forerunner of rhinitis, but may be due to other and physiological causes. The swelling of the mucous membrane of the vestibule and anterior portion of the septum (cartilaginous portion) is always inconsiderable, except in the latter portion of the hypertrophic stage, when it is often excessive.

In their perfect physiological condition, the nasal passages are moistened by a scarcely perceptible halitus which varies in amount according to the condition of the surrounding atmosphere and other external and internal causes. The existence of mucus must be regarded as pathological, and therefore incompatible with a perfectly healthy condition of the nasal passages. While the secretion of mucus may be due to temporary causes (local or systemic irritation), it is always present in greater or less amount in the earlier stages of rhinitis. The more or less constant presence of mucous secretion within the nostril is therefore indicative of commencing inflammation.

The hypertrophied nasal membrane may be mistaken for a polypus, or, if situated on the septum, may be confounded with a deflection or outgrowth of that structure. The ordinary gelatinous polypus is much paler in color than the hypertrophied membrane, and presents usually a peculiarly brilliant reflection of light, which often leads to its detection in the upper and deeper portions of the nostril when no distinct growth is visible or suspected. Occasionally a somewhat similar reflection is observed in the hypertrophied, or even normal, membrane of the central portions of the cartilaginous structures, and may be mistaken for a growth. The red color of the hypertrophied membrane is usually uniformly distributed, while in the gelatinous polypus the enlarged vessels are thrown out in bold relief against a dull white or pale pinkish background. The vessels of the polypus, moreover, are seen to run from above downward, while on the turbinated bodies the direction is more commonly horizontal. The gelatinous mucous polypus is distinctly pedunculated, and its mobility may readily be determined by the probe or nasal sound; or, if firmly impacted between the walls of the nostril, its pedunculated character may be brought into view, and its mobility may be demonstrated, by the artificial contraction of the turbinated tissues by means of cocaine. The application of this drug to the membrane will cause mere puffiness of that structure to disappear, while it only partially affects the color of a polypus. By closing the mouth and forcibly expelling the air through the nose, displacement and forward movement of a distinctly pedunculated polypus will occur, while an hypertrophied membrane remains unmoved.

The gelatinous polypus is intensely hygroscopic, while the same amount of moisture will not necessarily affect the nasal membrane. Pressure on a polypus with the probe communicates to the hand the sensation of a soft fleshy body, and when some force is used, it bleeds readily, and also imparts a sort of crackling sensation to the finger of the operator. The hypertrophied membrane, on the other hand, though often yielding and resilient, has a hard bony foundation, which is readily detected upon pressure. Nasal polypus—and this is especially true of the fibrous or fibro-cellular variety—is often, though by no means always, confined to one nostril; while in the hypertrophic stage of catarrh both cavities are, in different degrees it may be, usually obstructed.

In hypertrophy the difficulty in respiration is principally in inspiration, while in polypus expiration is the act most commonly interfered with, the growth often acting as a ball-valve. A large polypus, or numerous small polypi, usually produce complete obstruction to both inspiration and expiration; in hypertrophy, the air way is rarely completely occluded. Unless the hypertrophy be very great, the voice is less distinctly nasal than when the nasal fossa is filled by a polypus. Polypi generally develop or spring from some portion of the middle meatus, while the most common seat of hypertrophy is the lower turbinated bone, and principally its posterior portion. Hæmorrhage from one nostril was formerly considered diagnostic of polypi; but in our present knowledge of nasal hæmorrhage in its relation to intranasal inflammation (see article on Nose, Hæmorrhage of the), this test can no longer be relied upon in the differential diagnosis.

In the posterior rhinoscopic image a mucous polypus can generally be distinguished, not only by its glistening appearance, but also by its position, filling or obstructing the dark spaces of the meatuses described above.

The confusion of a hard, sessile, fibrous polypus situated in the deeper portions of the nostril, with an hypertrophied condition of the turbinated bodies, is sometimes a difficult matter to avoid; and this becomes more easily intelligible when we consider the anatomical mode of origin of many of these growths. The differential diagnosis between a posterior hypertrophy and a fibrous polypus, either originating in the nasal cavity or springing from the posterior ends of the turbinated bones and septum, is occasionally perplexing, and some confusion has arisen in the separation of the two conditions. Indeed, my examinations show that a not small proportion of the so-called fibrous polypi of this locality are nothing more nor less than enormously hypertrophied and pendulous turbinated bodies. It should also be remembered that now and then true fibromata, with sessile bases on the anterior naso-pharyngeal wall, may, instead of going downward, send one or more prolongations into the nasal fossæ, and thus further complicate the diagnosis. A mistake may, however, be prevented by keeping the diagnostic appearances of the hypertrophied tissue carefully in mind, and by attending to the fact that a fibrous polypus presents either a smooth or a distinctly lobulated appearance. Surgeons of wide experience in these matters will doubtless recall cases in which the fibrous polypus, originating by one or more pedicles in the nasal and accessory cavities, has sought the direction of least resistance, and presented at the posterior nares as a hard, immovable mass, easily mistaken for an hypertrophied turbinated body. When we consider the mode of origin and growth of nasal polypi, and the manner in which they often fill the meatuses and destroy the normal anatomical relations of the parts, it is not surprising that, in the limited rhinoscopic picture and in the case of subjects difficult to examine, mistakes of this kind now and then arise.

On either side of the septum posteriorly are found, in the normal condition, two bulging hemispherical bodies, which are composed of erectile or contractile tissue, and care should be taken not to confound them with either polypi or true hypertrophy. In this climate it is rare to find the posterior nares in a condition which altogether meets the requirements of absolute anatomical and physiological perfection. The posterior ends of the inferior turbinated bodies are very frequently of an unnatural color and uneven shape, and this apart from any inconvenience to the individual. The novice, therefore, should hesitate before operating on all such cases, simply because the posterior nares do not present the appearances seen in diagrams and anatomical plates.

Cystic tumors of the posterior nares are exceedingly rare, but it would be well to bear their possible existence in mind in a doubtful case. Exostoses and hypertrophic enlargement of the turbinated bones themselves, and various malformations of the bony framework of the nasal fossæ, either congenital or acquired—as, for example, in the altered anatomical relations of the nasal chamber left after necrosis and the expulsion of diseased bone—so alter the normal appearance and position of the parts that it is well to call the attention of the beginner to their possible presence.

To the careful observer the confusion of hypertrophic inflammation of the septum with deflection or enchondrosis of that area ought not to happen; but, at the same time, it should be remembered that distinguished surgeons have made this mistake, and subjected patients to needless pain by bungling attempts at removal.

It may perhaps be safely said that perforation of the septum never occurs as the result of a simple catarrhal inflammation. It may occur from traumatic causes, as the constant injury by the finger in picking the nose, but the most common cause is syphilis. At the same time it should be remembered that it may result from lupus, malignant disease, and certain blood affections such as typhoid fever, diphtheria, and other acute infectious diseases, and that it may be due to the corrosive action of chemical agents. It is a familiar accident among the workers in chrome,* arsenic, mercury, and other similar agents. It may also have resulted from the incautious use of caustics, and in rare instances it is congenital.

An enormously engorged condition of the turbinated structure may possibly be confounded with an angiomatous tumor. Indeed, certain cases of so-called angiomatous tumors may probably be referred to vascular changes in the turbinated bodies. There is also another condition, which I have described elsewhere,[41] which rarely occurs, it is true, but which may possibly be confounded with both angioma and turbinated hypertrophy. It is a peculiar condition of enlargement of the turbinated structures, associated with prolapse, and forming a dense, dark reddish, hard, fleshy mass or tumor, which may hang free in the nostrils, or may rest on the floor of the inferior meatus. Such tumors or masses may constitute, in some cases, the initial stage of the future angioma.

The diagnosis of atrophic rhinitis is sufficiently easy, and will depend upon the exclusion of the affections causing "ozæna," and on the history of a pre-existing

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* Among the many inconveniences from which those directly engaged in the manufacture of chrome suffer, the most prominent, perhaps, consist of a group of symptoms referable to the respiratory tract, and especially the nasal cavities and their dividing septum. In the chrome factory of Baltimore the workmen employed in the chambers where the bichromate is made, almost invariably acquire perforation of the cartilaginous portion of the septum from the irritating and corrosive action of the fumes and floating dust evolved during the chemistry of its manufacture. This destruction of the cartilaginous septum appears to be the most prominent anatomical lesion, and occurs with such striking frequency that it may be looked upon as a characteristic and constant sign of this particular form of chrome poisoning. Perforation occurs, as a rule, with great rapidity: generally in a few days after exposure to its exciting cause. I am told by one of the workmen, who has been engaged in the factory for over fifteen years, that extensive destruction of the cartilage sometimes takes place within twenty-four to forty-eight hours. It is commonly preceded by general congestion of the mucous membrane, with more or less epistaxis, or by the symptoms of a well-defined coryza, such as obstruction of the nares, heaviness of the head, discharge of limpid fluid, sensation of foreign body in the nasal passages, reflex acts, etc. The mucous covering of the septum is quickly destroyed and the cartilage laid bare. Necrosis of the latter soon follows, and a communication between the nostrils is established by a gradual corrosion and breaking down of the septum, which produces finally a round or oval perforation. Or, the same result may be accomplished by the exfoliation of necrotic plates or layers of the cartilage, presenting the appearance as if they had been punched out by instrumental aid.

When the mucous membrane is destroyed a crust forms, which becomes closely adherent, and beneath which the corrosion of the septum proper goes on. After perforation takes place there is also a tendency to crust formation about the edges of the artificial opening. It is possible that the crusts may act to a certain extent as protective agents, thereby preserving the edges of the cartilage against the invasion of the floating particles, and hence limiting the further progress of the corrosive action. The latter process seems, in the vast majority of cases, to be confined to the cartilage, and very extensive destruction of the latter may occur without change in the external appearance of the nose. The most frequent seat of perforation is the antero-inferior portion of the cartilage—or, in other words, that portion which is most directly exposed to the action of the irritant particles. The perforation itself varies greatly in size. I have seen almost complete destruction of the cartilaginous septum, nothing remaining but the merest rim of tissue to support the fleshy structures of the external nose.

Although this is its most frequent seat, the ulcerative process is not confined to the septum, but is occasionally met with in other portions of the nose, as the turbinated bodies and nasal pharynx. It is more likely to occur in the latter situation, as the voluntary removal of foreign substances from this cavity is more difficult than their expulsion from the nasal chambers. Ulceration, moreover, is also more likely to persist in the former than in the latter situation. The lower pharynx is also sometimes the seat of more or less clearly defined ulceration, and the same is probably true of the larynx, although I am unaware of its occurrence in the latter. The condition of the lower respiratory tract generally found is that of inflammation, characterized by intense redness, moderate swelling, with tendency to inspissation of secretion. These appearances are found as far down the trachea as the laryngoscopic view extends. In fact, the mucous membrane of the entire naso-bronchial tract is intensely hyperæmic, more or less swollen, and presents at various points evidences of capillary hæmorrhages and small extravasations of blood. These appearances are more pronounced in the respiratory region of the nose. Ulceration also attacks the hair follicles in the nasal vestibule, causing a dryness and itching, with falling out of the vibrissæ.

As the ulcerative process in the nose and retronasal space advances, the secretion becomes muco-purulent, and portions of the necrotic tissues are expelled either in shreds or as a fine detritus mingled with the greenish-yellow discharge. In some the nasal flux is inconsiderable, and perforation of the cartilage may occur without the knowledge of the individual. There is often a great tendency to the formation of hard, laminated, or tough, leathery crusts, which adhere to the structures with great tenacity, and whose expulsion is attended with considerable difficulty. They may be expelled through the anterior nares, or may fall into the lower pharynx and be expectorated. Occasionally detachment occurs during sleep, the crust entering the laryngeal vestibule and giving rise to suffocative paroxysms.

Accompanying the catarrhal symptoms there is a sensation of heat or burning in the nose and throat, and sometimes intense headache, which is referred to various portions of the cranium. The sensation experienced is sometimes described as that of a bubbling or boiling, as of water in a caldron, in the vertex, and constitutes one of the most annoying features of the case.

Attention has already been called to the inspissation of the secretion and its tendency to crust formation. Notwithstanding such disposition, however, and the profuse and purulent character of the discharge, there is little, if any, tendency to the development of a condition of ozæna. Fetor is, so far as my experience goes, always absent, or at least is never a prominent symptom. This I consider a point of especial interest. The absence of odor here is certainly in a measure due to the fact that the agent which excites the discharge at the same time destroys the forms of life upon the presence of which the fetor of such conditions is supposed to depend.

The corrosive action is not always limited to the mucous membrane of the nose and throat. Purulent inflammation of the drum cavities also occurs, with perforation of the tympanic membrane and the consequent development of otorrhœa. This is in part, doubtless, due to extension through the Eustachian tubes, but it is conceivable that the membrane may become corroded by direct contact of the bichromate dust.

There appears to be a decided limit, however, to the destructive action of the corrosive agent on the cartilage and mucous membranes, a certain self limitation of its corrosive power which agrees with the known comportment of the poison in the presence of organic matter. For, as is well known, every molecule of matter with which each molecule of chromic acid comes in contact, is not only immediately destroyed, but the acid, in accomplishing such destruction, is itself rendered innocuous by its conversion into an insoluble oxide of chromium.

Experimental chemistry has closely concerned itself with the investi hypertrophic catarrh. The disgusting peculiar odor should be carefully distinguished from that which occurs in the presence of bone disintegration from caries and necrosis. Each is separate and distinct, and the resemblance of the two baffles all the powers of description. By alternately closing the patient's mouth and nostrils, the source of the odor may be determined.

Finally, it should be borne in mind that unilateral catarrh may be symptomatic of various neuralgias of the fifth nerve, syphilis, foreign bodies, tumors, empyema of the antrum or accessory cavities, or may occur as a complication of acute and chronic middle-ear catarrh from peritonsal inflammation or other causes. I have seen it associated with parenchymatous conjunctivitis as the result of exposure to a high wind. Unilateral swelling of the turbinated bodies, with other evidences of catarrh, occur during the [illegible] excitement of the menstrual period. It occasionally occurs, too, as a reflex phenomenon, from a carious tooth, cerumen in the ear, or other forms of irritation of the auditory meatus. It may also result from injudicious instrumental or chemical irritation of the nasal cavity.

When called, then, to a case of unilateral discharge from the nose, or excess, the practitioner should search for some such cause as those just mentioned, and should direct his treatment accordingly.

COMPLICATIONS AND SEQUELÆ.—The possible complications and sequelæ of chronic nasal inflammation are of the most manifold character, and may be extended to almost every organ of the body. So important is a proper discharge of the nasal functions not only to the structures directly involved, but also to the general welfare of the individual, that the abrogation or suspension of the vital properties of the intranasal tissues may be looked upon as one of the most serious obstacles to the enjoyment of normal physiological life. This is especially true in early childhood, when growth and development are going on with rapidity, and when the demand for healthy respiration is accordingly all the more imperative. It is a remarkable fact that congenital occlusion of the nares seems to be incompatible with the viability of the fetus, and the bad health and stunted growth of children suffering from nasal obstruction is a matter of every-day occurrence, unfortunately too frequently overlooked.

Inflammatory affections of the nasal passages derive much of their importance from their influence on the functions of respiration, olfaction, audition, and voice production, as the starting-point of diseased conditions of the nasal pharynx and other accessory cavities, and the nasal duct. The affections of those organs to which it gives rise have been fully discussed in other portions of this work. The most common is inflammation of the nasal pharynx (see article on this subject in Vol. V.). The extension of the inflammatory process into the ethmoidal, or even sphenoidal, cells, is also met with, and is often a most difficult sequel to deal with. Obstruction of the nasal duct and dacryocystitis are occasional complications; but both these affections and the extension of inflammation to the frontal sinus are comparatively seldom met with, although popular belief would seem to indicate that catarrh of the latter cavity is the prolific source of all the headache of catarrhal rhinitis. In regard to the relation of inflammatory conditions of the antrum maxillare to intranasal processes, I would like to offer some suggestions.

While I am convinced that the chronicity of certain forms of nasal disease, the persistency of a fair proportion of neuralgic affections (and other reflex neuroses) of the head and face, are traceable to latent or unsuspected chronic antral inflammation, while it is doubtless true that affections of the maxillary sinus often run their course unrecognized during life, the secondary implication of that cavity in acute and chronic inflammatory processes originating in the nasal passages is, comparatively speaking, rare.

Inflammation of the maxillary sinus may result from congenital or acquired defect of the naso-antral aperture, or from its closure by the swollen and hypertrophied nasal tissue, polypi, cysts, etc., conditions which may favor the retention and decomposition of the antral secretion. Inflammation from this cause, however, occurs less frequently than is universally taught by inference from purely theoretical considerations. I base this assertion not only on clinical observation, but also on the results of post-mortem investigation. Those who choose to investigate the anatomical aspect of this question will be amazed to find how infrequently the mucous covering of the sinus participates in the inflammatory conditions of the nasal fossa. It is the rule to find the most marked hypertrophy of the nasal tissues, and even complete atrophy, associated with a normal condition of the sinus. What is the explanation of this fact?

On the nasal aspect of the naso-antral opening is a continuation of the erectile tissue of the turbinated bodies, which in all probability serves the useful purpose of excluding from the cavity of the sinus, by means of the vascular barrier involved in its erection, various irritants derived from the external world and nasal passages. This tissue ceases abruptly at the antral aperture. On the other side of the opening lies the peculiar, loose vas-

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[illegible]

cular membrane of the sinus. In the majority of cases this zone of erectile tissue constitutes the extreme anatomical limit of the nasal inflammation. The thin, loose, serous-looking membrane of the sinus differs essentially from the nasal mucous membrane, and especially that portion which surrounds the entrance into the maxillary sinus, and the abrupt transition of the one tissue into the other would therefore militate, on theoretical grounds, against extension of the inflammatory process into the antrum. In other words, I believe that the so-called extension of inflammatory action from the nasal passages to the antrum—the secondary inflammatory implication of that cavity—is of comparatively infrequent occurrence; and that, when inflammation of the sinus from extension is assumed, the condition will be found, on post-mortem examination, to be one of simple congestion, with possibly some accumulation and retention of the antral secretion from mechanical causes. Even if the amount of secretion be temporarily increased, the great power of absorption possessed by the membrane of the sinus will usually suffice to make it a matter of secondary importance.

I am inclined to believe that too much stress is laid upon the decomposition of antral secretion as a factor in the production of inflammation. Take, for example, a simple coryza. With the general erection of the turbinated tissues the orifice of the antrum is completely closed, congestion follows, with possibly an increased secretion of the antral fluid. Whether this secretion, thus hermetically sealed, so to speak, in the antrum, undergoes decomposition before the patency of the opening is restored and the air gains admittance, is questionable; but, on the other hand, that decomposition does occur is beyond dispute, for, when the swelling from the acute rhinitis subsides, the aperture becomes free, and, in some instances, the fetid antral secretion is discharged into the nasal passages, a fact which accounts for the peculiar fetor of the expired air from the nostrils which is sometimes observed at the close of a severe coryza.

One of the most familiar sequels of chronic nasal inflammation is the common myxomatous, and even fibrous, polypus. In some cases the membrane is studded with small papillomatous or fibrous growths. I have also met with a veritable *trachomatous* condition of the nasal membrane similar to that found in the conjunctiva. Occasionally cystic degeneration of the membrane is seen, and, in very rare cases, perichondritis and abscess of the septum, and even rhinoliths, have been observed. In long-standing cases hypertrophic changes in the turbinated bones themselves and septum may develop, and deflection or malposition of the latter is now and then due to this cause. Nasal obstruction may even lead, in very young subjects, to asymmetrical conditions or imperfect development of the nasal and accessory chambers, and other portions of the skull on the side corresponding to the seat of obstruction. Indeed Ziem[42] has shown experimentally that in certain cases nasal obstruction may be an important factor in the production of asymmetrical conditions of the cranium.

Perforation of the septum rarely, if ever, occurs as the result of simple inflammation (*vide infra*). Thickening and slight flattening of the bridge of the nose, with sometimes pain on pressure, is not infrequently met with in simple chronic catarrh, and is probably the result of a localized nasal perichondritis. This should not be confounded with the very conspicuous flattening and consequent separation of the eyes which occurs in long-standing post-nasal obstruction.

Hæmorrhage is a common complication, and has been fully considered in the article on Hæmorrhage of the Nose (Vol. V.). The host of interesting neurotic phenomena which complicate this class of affections have also been elaborately discussed in another portion of this work (Vol. V., article, Nose, Neuroses of the).

Osteitis is rarely, and necrosis probably never, the result of a simple catarrh. It is a matter of common experience that various forms of excoriated mouth depend upon a disordered stomach, the so-called herpetic diathesis, etc., but occasionally cases occur which cannot be referred to these conditions, whose dependence on hypertrophic nasal catarrh must be inferred from their disappearance with the cure of the nasal affection. Several factors are probably concerned in their production, among which mouth-breathing plays an important part, and, possibly, the disordered condition of the stomach occasioned by the nasal discharge. The inflammation of the conjunctivæ, which is so often observed in connection with nasal catarrh, is generally explained by the extension of the inflammatory process through the nasal duct; but I am inclined to regard it in the majority of instances as a reflex vaso-motor phenomenon, the vessel dilatation being kept up by the constant irritation of the sensitive nasal area. In like manner I would explain the recurrent herpes and keratitis which have been observed in connection with this disease, the phenomena in these cases being called forth by trophic disturbances. Zaufal[43] has found trachoma a frequent complication of ozæna.

In nasal obstruction of long standing, chronic inflammatory changes are sometimes induced in the bronchial and pulmonary mucous membrane, which are exceedingly difficult to deal with even after the original cause is removed, and this has doubtless given rise to the popular idea that "catarrh" is the forerunner of consumption. Certain it is that nasal obstruction predisposes, other things being equal, to inflammatory conditions of the respiratory tract, and that the practical physician cannot afford to overlook the influence which it exerts in their production. In this country the vast majority of the cases of chronic laryngitis originate primarily in disease of the nose, and many a winter cough is allowed to go on from bad to worse because of failure to recognize this relationship. I am furthermore convinced that nasal obstruction may and does awaken diseased states of the lungs, and *in an individual so predisposed may favor* the development of pulmonary consumption. Fränkel states that emphysema frequently coexists with nasal stenosis, and Kussmaul believes that acute hyperæmia of the lung may be produced by the forced inspiration of the air. The vesicular murmur is weakened, feeble and shortened in inspiration, and only approaches the normal when deep inspiratory efforts are made. Frequently mucous and subcrepitant râles can be heard in different portions of the chest. Attention has been called to certain deformities of the chest-walls consisting chiefly in malposition of the bones and loss of power in the muscular covering. I believe these deformities to be rare, except in very young children.

The influence of nasal obstruction in such cases is of course purely accidental and mechanical. Although the theory of the direct pathological relationship between simple nasal disease and tuberculosis of the lungs has been gravely advanced by more than one observer, it seems scarcely necessary to remark that we must accept observations of this kind with the utmost caution, and require more abundant proof of the alleged facts than those already in our possession.

There is one symptom of nasal obstruction to which especial importance must be attached, and for which alone the physician is often consulted. *Dyspnœa on exertion* is one of the most annoying features of the case. Such patients complain that in talking they must frequently pause for breath; that in going upstairs walking rapidly, or running—in fine, in all bodily operations which require unusual exertion, they get very readily out of breath. Difficult breathing is also present when the mouth is occupied or closed, as in swallowing, smoking, etc. They are accordingly constantly haunted by the dread of heart disease and consumption. Physical examination, however, fails to detect any cause for the dyspnœa. At times the breathing is perfectly normal and vesicular; at others a few small mucous râles may be heard posteriorly in the inferior lobes, or in the infrascapular and mammary regions.[44]

PROGNOSIS.—The prognosis of a disease is one of the most difficult chapters of its history to write. Assertion must be followed by indefinite qualification, and there are so many things to take into account, that the study of each case on its individual merits becomes the only rational way to reach a satisfactory and intelligent opinion.

There are two great influences which particularly affect the prognosis in chronic catarrhal diseases of the upper air tract: climate and individual environment. Pronounced nasal inflammation of long standing, in any of its stages, is a difficult affection to deal with in a climate such as that described elsewhere (see Vol. IV., Article on Larynx, Catarrhal Affections of) as most productive of the disease, and especially is this true if the individual, either from compulsion or design, does not live under the guidance of the common law of health.

The prognosis, in general, will depend in many cases upon the constitution, surroundings, habits, occupation, and a host of other influences pertaining to the individual, and will accordingly be determined by an indefinite number of agencies. This will be the more clearly understood upon reference to the remarks in Vol. IV. of this Handbook, on the Etiology of Catarrhal Affections of the Upper Air Passages. In this section we shall speak of the prognosis in uncomplicated cases living under fairly good hygienic conditions.

In its incipient stages the affection is always amenable to treatment, but in the vast majority of instances the patient either is unaware of the insidious approach of his disease or is disposed to make light of it, and therefore only consults a physician when the inflammatory process is firmly entrenched in the nasal membrane, and permanent tissue-structural changes have taken place.

In the first stage the prognosis may be written down as good. It is, however, often a very difficult and rebellious affection to cope with, even under the most favorable circumstances, and relapses frequently occur after the disease has been apparently effectually eradicated. In this as in all other forms of catarrh of the upper air-tract, different individuals present the most varying degrees of susceptibility to treatment and recuperative power. In some the disease will yield with great rapidity, a few weeks sufficing to produce a cure, while in others months, and even years, are necessary to bring about a like result.

In the second stage the outlook is also generally good, and it is at this period that some of the most brilliant results of nasal surgery have been achieved. Relief can always be obtained, and permanent cure is often the result. Indeed, the prognosis in nasal disease very often depends upon the amount of surgery in the case.

In the early stage of atrophy the prognosis is much less favorable, while in advanced cases it is unquestionably bad. Under favorable circumstances it is possible to arrest its progress, and in every case relief can be obtained and the nose kept under control, but it is naturally impossible to restore the functions of an organ whose physiological properties have been hopelessly destroyed, and the atrophied structures must therefore be placed, with the contracted liver and kidney, in the list of incurable affections.* When "cure" of atrophic rhinitis is spoken of, it almost invariably refers to a condition of comparative comfort.

It may be well to state here that it occasionally happens that extensive atrophy of the nasal structures exists with little or no marked discomfort to the individual. Whether the structures be congenitally small, whether the condition present is the legacy of a former syphilitic or other local affection, or the remains of the destruction left by chronic or other corrosive chemical agents, are sometimes difficult to determine; but the fact remains the same.

Coexisting atrophy of the fauces makes the prognosis proportionately more grave.

GENERAL RULES OF TREATMENT.—The general principles governing the rational treatment of the different stages may be summed up briefly in the following propositions:

In the early part of the first stage the treatment is mainly hygienic (bathing the skin, ventilating the nasal passages, attention to general health, protection of nasal passages from direct or indirect sources of irritation, removal, if possible, to an equable climate, etc.), and consists in many cases simply in the search for and removal of the cause (local or reflex irritation, general systemic disease, lowered constitution from various causes, excesses, surroundings of patient, etc.). At this period local treatment is often unnecessary, and in some cases harmful. In other cases great benefit is derived from the judicious use of detergent, alterative, and astringent preparations, applied as far as possible to the diseased surfaces alone, in the form of solution or mixture with some such substance as cosmoline, glycerine, vaseline, etc.; or these substances may be advantageously used unmedicated. In a certain proportion of subjects the administration of remedies to control reflex excitability of the nerve centres is productive of good.

The treatment of the second period of this stage must be carried out on the same general principles as above. Remembering the condition of the contractile elements of the intercellular walls, the physician should take measures to restore their loss of power (strychnine and electricity are occasionally useful). If the simpler means fail, resort may be had to the galvano-cautery or to electrolysis.

In the above periods, medicines in solid form (e.g., powders) are absolutely contraindicated as tending to increase the irritation and to hasten the coming of the hypertrophic stage.

The management of the first period of the hypertrophic stage consists in a combination of the above methods. Here surgical procedures are more justifiable. In the second period of this stage the treatment is essentially surgical, and consists in the removal of the obstruction, in procuring thorough cleanliness of the nasal passages, and in attention to the general principles indicated above. Solid remedies are contraindicated. The general treatment of the third stage is tonic and hygienic; the local treatment is palliative, and consists in keeping the parts scrupulously clean and lubricated.

The methods of cleansing the nasal passages are the spray, the nasal douche, irrigation by the anterior and posterior nasal syringe, the nasal bath (pouring the liquid from a spoon into the nares), direct inspiration of the liquid through the nose (the so-called "drinking" through the nose), or, finally, regurgitation through the nasal pharynx into the posterior nares. When the mucus is very tenacious, the physiological act of sneezing may be provoked in order to assist in its expulsion.

Of these methods the most effective and least objectionable is the spray, except when hot liquids are employed; for, in the separation of the liquid into finely divided spray particles, the temperature is so lowered that it practically amounts to a cold injection. For ordinary purposes a fine spray is sufficient, but when the secretion is inspissated or closely adherent, a coarse spray is often necessary.

The nasal douche is too dangerous a remedy to be extensively employed, for it often subjects the patient to inflammation of the middle ear. Since Roosa first called attention to this fact, there has been an almost daily accumulation of evidence to warrant the condemnation of its indiscriminate use. Acute inflammation and abscess of the middle ear have repeatedly followed its use, and in one case death was the result.

My experience agrees with that of Beverley Robinson, that chronic inflammatory infiltration of the turbinated tissues results sometimes from its employment, and I have known cases in which there could be no reasonable doubt that chronic middle-ear disease was caused by its use.

When the nasal pharynx is filled with secretion, gargles are sometimes of benefit, but the sphere of their usefulness is limited. Even by Trœltsch's method very little of the fluid reaches the posterior part of the pharynx, and as all communication is shut off between the upper and lower pharynx in the act, the remedy never reaches the spot it is designed to medicate. The medicament may act, however, mechanically by producing muscular contraction and thereby dislodging mucus from the naso-pharynx. A gargle of water will accomplish the same result.

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* [illegible]

Regurgitation of the fluid into the naso-pharynx is an unphysiological procedure and a roundabout way of accomplishing a great deal of possible harm with considerable difficulty and personal inconvenience. A better method is to lie flat on the back, with the head inclined slightly downward, and allow the fluid to gravitate into the pharynx.[*]

Whatever method be employed, it should be remembered that the constant use of too much water in the nose if often productive of evil, for the reason that it produces a constant saturation of the intranasal tissues, with consequent disease and destruction of function. Sprays are not to be employed indiscriminately, nor for too long a period of time. By the spray method water may also gain access to the middle ear, and I have known in several cases the use of the post-nasal syringe to give rise to acute inflammation and even abscess of that cavity.[†]

The indications in the treatment of hypertrophic nasal inflammation may be considered under the following heads:

1. *Removal of the Obstruction.*—If the catarrh be dependent upon a deflected or dislocated septum, or upon other irregularities in the nasal chambers, these must, of course, be rectified before we can proceed with the treatment of the case. If adhesions, from syphilis, the essential fevers, misuse of caustics, etc., exist, they must be divided. If the pharyngeal tonsil be hypertrophied, or if growths exist in the nose or the retronasal space, they should be removed. If, as is often the case, the faucial tonsils be enlarged and indurated, they should be excised. It is useless to temporize with sprays, caustic applications, and other palliative measures.
2. The nasal and retronasal chambers should be thoroughly cleansed and *kept clean.*
3. The congested or inflammatory condition of the naso-pharyngeal membrane which remains should be treated on the general principles which govern the management of simple inflammation of this structure, and the patient should be put under the hygienic conditions which favor a return to the normal state.

To remove the element of obstruction a number of methods have been suggested—caustics, dilatation with bougies, sponge-tents, etc., galvano-cautery, thermo-cautery, electrolysis, injections, the knife, forceps, and cold-wire snare.

Caustics.—The caustics chiefly employed are chromic, glacial acetic, and nitric acids. Of these, chromic acid is probably the best. Various forms of applicators of more or less ingenious mechanism, are sold in the market, but a small pointed glass rod, as recommended by Dr. Donaldson, of Baltimore, answers for all ordinary purposes. Before applying the acid the parts should be thoroughly cleansed, and the healthy portion of the membrane protected from the possible inroads of the acid. A number of devices have been suggested, such as applying the caustic through a speculum resembling the Gruber ear speculum, or some similar contrivance, anointing the nares beforehand with glycerine, vaseline, etc.; various forms of applicators, etc.; but with a well-dilated nostril and a steady hand this paraphernalia may be in the majority of cases disregarded. The contour of the nasal vestibule varies so much in different individuals that it becomes necessary for the specialist to have quite a variety of dilating apparatus at hand. The speculum which I have found most generally useful is the one shown in Fig. 4891.

The simple principle upon which this instrument acts is that involved in the ingenious eye speculum[45] and gag[46] devised by Dr. Russell Murdoch, of Baltimore.

Into the nasal extremity of each blade is fitted an ivory shield, which may be replaced, if necessary, by other dilating apparatus. At right angles to the distal end of one blade is a rectangular bar, upon which a well-fitting square sleeve, attached to the distal extremity of the other, slides with ease. This sliding motion is accomplished by means of slight pressure on the button or handle which juts out from the sleeve. In using the speculum, the ivory shields are brought together, introduced closed into the nostril, and separated by pressure on the button with the forefinger, counter-pressure being brought to bear on the free extremity of the bar with the thumb, or *vice versa*, according to the position in which the blades are introduced.

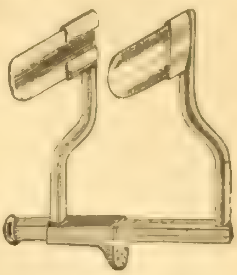

Fig. 4891.

The pressure of the sides of the nostrils arrests the sleeve at any desired point, thus furnishing the simplest possible principle of self-retention. A touch upon the button releases the blades from their fixed position, thus permitting instantaneous removal of the instrument. The upper and under surfaces of the rectangular bar are roughened to increase the amount of friction.[*]

If the glass rod be slightly warmed and plunged into a bottle of the crystals of chromic acid, a few will adhere and be immediately deposited on the diseased surface. The acid is so deliquescent that, when exposed to the air, the crystals rapidly liquefy, and this solution is frequently employed in the place of the crystals themselves. When the acid is applied, lachrymation, sneezing, cough, and various other reflex phenomena appear, and considerable pain may or may not be complained of. The pain is, however, very fugitive, and in the course of a few moments is generally gone. The nostril feels "stuffy" for a day or two, as in a common cold in the head, and after the lapse of from three to seven days the diseased tissues come away, either as well-defined sloughs or finely divided particles, in the discharge. The sudden application of the acid causes at first collapse of the normal turbinated structures, and temporary freedom of breathing through the nostril, but the subsequent effect is to cause obstruction until the sloughing process is over. A curious reflex that is often met with in the application of an acid to the nasal mucous membrane, is the sudden and immediate impression made by it upon the sense of taste. When a drop of the acid is applied to the turbinated bodies, the patient will often exclaim suddenly that he tastes the medicament. In the vast majority of instances the application of caustics to the nasal membrane is productive of no evil result. The sloughing process is sometimes disagreeable, and in some persons an annoying conjunctivitis with œdema of the lids may complicate the case, but with this exception I have never seen any serious after-effects.

Dilatation with graduated sounds (Clinton Wagner), *bougies, sponge-tents* (J. Solis Cohen), etc., has been employed to cause absorption of the indurated tissues, and is doubtless often of at least temporary good; but so much more success can be attained by other less painful, more expeditious, and more certain measures, that I am inclined to regard dilatation as contra-indicated except in very exceptional cases.

Galvano-cautery.—The galvano cautery in the hands of a careful operator is one of the most generally useful procedures for the removal of nasal obstruction. Whatever form of instrument be used, the most important point to be looked to is the temperature of the knife or snare—the condition known as cherry heat being the least painful and dangerous, and more generally efficacious than the higher or lower degrees of temperature.

The method of operating will depend upon the nature of the obstruction and the judgment of the operator. A common and very good method is to make linear, parallel incisions along the antero-posterior axis of the turbinated knife or a number of lateral incisions converging at a common point in the interior of the hypertrophy. In many cases I prefer a median incision of the turbinated body after the method described elsewhere (Vol. V. of this Handbook, p. 341). Sufficient patency of the nostril is secured, the erectility or contractility of the tissues is brought under control, and the patient escapes with very small loss of function.

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[*] The method of regurgitation of wines and whiskeys into the nasal pharynx employed by wine-tasters, is not infrequently the source of post-nasal inflammation.

[†] See also article on the Treatment of Chronic Laryngitis, Vol. IV., for further rules of treatment.

[*] The speculum is made by Wilson & Co., of Baltimore. See Medical News, Philadelphia, December 6, 1884.

It will often be found sufficient simply to make a small number of punctures with a fine-pointed electrode in the swelling, especially in the condition of chronic puffiness described above. Or, if the nature of the obstructing portion [illegible], the loop or snare may be employed. This latter operation may be followed by considerable hemorrhage, if the tissue be not slowly severed. Finally, various other methods may be employed according to the peculiarities of the case and the ingenuity of the surgeon.

The electrode should be introduced unheated into the nostril, and the current turned on only when the incisions are to be made. Before its introduction the nasal fossa should be thoroughly cleansed of all secretions, in order not only to facilitate accuracy in placing the knife, but also to avoid the sudden reduction of the temperature of the electrode by the nasal secretions.

The amount of pain varies greatly with the susceptibility of the individual. Some bear it without experiencing any disagreeable sensation, while others complain seriously. Cocaine annuls the pain, but does not destroy the temperature sense.

My attention was first called to the isolation of the temperature sense by means of cocaine through an observation of Dr. William Warfield, of this city, who noticed, during an operation on the eye under the anæsthetic influence of this drug performed by Dr. Russell Murdoch, that, while the sensibility of the conjunctiva and cornea was abolished, the contact of the instruments was felt as a distinctly cold sensation. Subsequently Mr. H. H. Donaldson, of the Johns Hopkins University, acting upon this hint, examined the eyes of two patients with reference to this singular fact, and discovered that, although the eye was rendered completely insensitive, the sensations of heat and cold were readily distinguished.

Struck with the original observation of Dr. Warfield, I experimented with regard to the isolation of the temperature sense in the nasal and oro-pharyngeal cavities. Six persons (hospital patients) were taken for the experiments. Having thoroughly anæsthetized the mucous surfaces of the soft palate, uvula, and nasal passages with a four per cent. solution of cocaine, a probe, which had been previously immersed in a mixture of ice and salt, was made to impinge upon the parts rendered insensible to contact and pain. A distinct sensation of cold was complained of in each instance. The opposite extremity of the same probe was then heated over the burner of a lamp used for laryngoscopic purposes, and its heated extremity carried over the anæsthetized area. While absolutely no pain was felt by any of those experimented upon, there was a marked unanimity of the answers given voluntarily in regard to the sensation of heat. In three of the cases a vesicle followed the application of the heated probe, and in one an acute pharyngitis developed, yet at the time of application no pain was felt, though the temperature sense remained intact. These observations are of interest in view of the fact that, while recent physiological research has rendered it probable that the sensations of heat and cold are distinct from those of pure contact and pain, it has heretofore been impossible to demonstrate the fact by the complete isolation of the temperature sense. It is accordingly obvious that its separation from the other senses may lead the way to some interesting physiological discoveries.

The electrode should be withdrawn unheated from the nostril, and the wound treated on ordinary surgical principles. After a period varying from five to fifteen days the sloughing tissues are eliminated, and cicatrization takes place. An excavated surface thus results which resembles somewhat the under surface of a mushroom, and this becomes gradually filled with cicatricial tissue. Scars in the turbinated bodies are often invisible to the inspector during life, from the fact that their surrounding engorged walls of erectile tissue hide them from direct inspection.

Many accidents have followed the too vigorous use of the electro-cautery, among which may be mentioned hemorrhage, acute inflammation and abscess of the nose, otitis, conjunctivitis, erysipelas, high fever, septicæmia, meningitis, and other serious affections. These complications would be less frequently met with if the galvano-cautery were employed less in the posterior portion of the nares, and its use confined to simpler operations. Apart from a temporary prolongation of the sloughing process, and an occasional rise of temperature after the operation, I have never met with any serious sequel, and can only re-echo the words of Clinton Wagner, that, "with a well-dilated nostril, proper illumination of the parts, a battery in thorough working order—care being taken that the platinum be not too thick to become raised to white heat instantly—and then with a steady hand and not keeping the contact [illegible] for more than a second or two at a time, accidents, as above described, need not be feared."

Thermo-cautery.—The method by thermo-cautery is rarely employed. Dr. Goodwillie, of New York, by whom the method was introduced, uses a modified Paquelin instrument with a glass speculum, and claims good results.

Electrolysis is inferior to, and less certain than, the electro-cautery in the treatment of the hypertrophic stage. In conditions, however, in which the cautery is contra-indicated, and in the state of chronic puffiness which represents the transition of the first into the second stage, it may be employed with advantage.

The number of cells used will, of course, depend upon the density of the tissue and the closeness of the circuit. It should be undertaken with caution, and the requisite number of cells be determined by tentative experiment. The battery which has given the most satisfaction is the dry chloride of silver apparatus of Mr. Barrett, of New York.

Injections of ergotine have been used with some success by Dr. T. Amory De Blois, of Boston, but the method has not passed into general use. It is, moreover, probable, in view of the structure of the turbinated bodies and their anatomical relations, that its indiscriminate use may lead to dangerous results.

Knife.—The use of the knife for the removal of the hypertrophic membrane is now scarcely ever resorted to, for the reason that, in addition to the risk from hemorrhage, a much more successful result may be obtained by other less dangerous methods.

Forceps.—Various forms of cutting and serrated forceps have been devised for the removal of the indurated tissues. So eminent a practitioner as Dr. Beverley Robinson, of New York, still recommends evulsion with forceps, but the general sentiment of authority regards this method simply as a matter of purely historical interest. The operation is intensely severe, and is easily replaced by simpler, more efficient, and less painful procedures.

Cold-Wire Snare.—Although these masses were probably again and again removed by the wire, as anyone can convince himself by referring to the standard surgical works of the last two centuries, their true anatomical significance and relation to nasal inflammation was not properly appreciated until Bigelow demonstrated the erectility of the tissues concerned in their development. The credit of urging the necessity of the removal of the hypertrophic mass with the cold-wire snare belongs to Dr. Jarvis, of New York. Prior to the introduction of the wire the galvano-cautery had been used both in this country and in Germany. In the latter country it was extensively adopted, and it is a noteworthy fact that Zaufal, who is an enthusiastic advocate of the snare for the removal of polypi, recommends the cautery for the hypertrophic masses of the turbinated bodies.

The use of the snare in the removal of intranasal growths dates from the time when Robertson published the account of his instrument in the *Edinburgh Medical Journal* for 1805. This was one step, and an important one, in the evolution from the ligature of the ancients to the apparatus in use at the present day. The Greeks and Arabs applied the ligature by means of a peculiar kind of forceps which is described and figured by Dionis, but it was not until centuries later that the cannula was introduced by Fallopius. This was variously modified by the surgeons of the eighteenth century, prominently by Levret, who, among other contrivances, used a double cannula with retention rings, and also, in common with Palucci and others, a single cannula divided at its distal extremity by a small partition. Various methods have, from the time of Riolanus, been suggested for the tightening of the wire, the most interesting of which is perhaps the knot-tightener of Graefe, which consisted of an outer piece sliding on the cannula, and thereby producing compression of the tumor. This was subsequently modified by Dupuytren, the ligature or wire being attached by several turns to a retention nut at the proximal extremity of the instrument, and compression of the mass secured by means of a quick screw, after the method in use at the present day. It was probably these instruments that suggested the snares of Robertson and Wilde, and led to the modifications of Hilton, Blake, Zaufal, Jarvis, and others.[55]

Whatever form of snare be used, the most important thing to be looked to is the character of the wire employed. Steel piano-wire, as recommended by Zaufal,[56] Jarvis,[57] and Bosworth,[58] is the one commonly employed, as it possesses considerable resistance and resiliency, and retains its original direction to a great extent when projected from the mouth of the cannula.

In performing the operation with the aid of the rhinoscope, the nostril is first dilated with the speculum, and the wire loop passed, under the guidance of a strong light, through the slit between the turbinated bones and septum, into the naso-pharynx. The nasal speculum is then removed, and the tongue depressed, either by an assistant or the patient himself, with a Türck or similar depressor. The mirror is then introduced with the left hand, the loop directed over the hypertrophy with the right, and the wire pulled home. The mirror and spatula are then removed, and the operation completed by slowly tightening the screw. When the pharynx is unusually small or narrow, the soft palate may be tied up, prior to the operation, by means of a rubber cord, whose ends are passed through the nostrils, brought out through the mouth, carried over the ears, and tied under the chin, after the method described by Wales,[59] or the uvula may be elevated by one of the combination tongue depressors in use among specialists. These latter accessories are, however, rarely necessary; the latter instrument, although theoretically an excellent auxiliary, will too often be found an embarrassing impediment, and the elevation of the palate will sometimes interfere with rhinoscopic examination by the involuntary salivation and gagging which it every now and then occasions. Although the rhinoscope facilitates the operation and renders it impossible to damage any of the tissues adjacent to that to be removed, it is in the majority of cases unnecessary, *provided* the changed relations of the parts be known and mapped out beforehand, and the touch be sufficiently educated to recognize the various parts with which the instrument comes in contact, and, therefore, to avoid needless injury to the sensitive structures that it traverses. The mode of operation which I generally adopt is as follows: The patient is seated in a tall, straight-backed, narrow-seated chair, with the head thrown slightly back against the head-rest (or supported by the arm of the operator). The surgeon, standing at the side of the patient to be operated on, and elevating the tip of the nose with the thumb of the left hand, passes the wire loop, having the requisite diameter and curve, into the nostril. In this position the cannula of the instrument will form an angle with the floor of the nostril, varying with the curve of the loop, and its subsequent passage into the nasal fossa will throw the shank of the instrument toward the median line. It should then be pushed slowly and gently backward and slightly downward, until the loop enters the naso-pharynx. Bearing in mind the distribution of the fifth nerve in the nostril, the snare should be kept as close as possible to the floor, hugging the inferior border of the septum, and avoiding as much as possible contact with the external wall. This not only facilitates its introduction, but lessens the tendency to reflex phenomena and painful sensation. The wire, being pliable, will adapt itself to the sinuosities of the nostril and pass the obstruction without difficulty. No force should be used; but if the cannula be arrested, firm and gentle pressure will nearly always cause it to glide past the obstruction. The patient should be directed to keep his eyes open, and avoid facial contortions, which militate against the painless passage of the instrument. In cases where the fossa is more or less completely blocked, gradual dilatation with rubber bougies will materially aid the subsequent passage of the instrument. As the loop passes through the posterior nares over the bulge of the muscular palate, the contraction of the latter can sometimes be felt as it elevates the distal extremity of the wire. The wire should be pushed back until it reaches the posterior pharyngeal wall, and then gently withdrawn, care being taken to avoid the swollen lips of the Eustachian tube. The handle is then pressed slightly inward toward the septum as it is withdrawn. This will usually bring the loop over the hypertrophied mass. The distal extremity of the cannula should now be pressed firmly against the turbinated bone, and the wire tightened by means of the screw. As the loop passes over the base of the palate, involuntary acts of deglutition sometimes occur, interfering with the adjustment of the wire. When the latter is properly placed, the presence of the growth within its grasp is easily recognized by the sense of resistance imparted to the finger in turning the screw. By this method the hypertrophied tissue may be removed without difficulty, and often with a very slight amount of pain. Where, from the extreme narrowness of the passage, the introduction of the curved wire gives rise to pain, it may be introduced straight, bending it subsequently with the forefinger introduced into the naso pharynx. In several instances I have facilitated its adjustment by the following device: A fine rubber cord is tied by one of its extremities to the wire loop; the other end is then passed through the nostril and carried out through the mouth. The snare is then introduced into the pharynx. By pulling the cord downward and outward, the wire is bent and carried over the growth. The subsequent steps of the operation consist simply in division of the mass. When, from anæmia or certain diathetic conditions, loss of blood is to be deprecated, the mass may be slowly severed, a half hour or more being consumed in the écrasement. In ordinary cases I have never occupied more than ten minutes in the operation, and although I have operated a great many times, have never seen a hæmorrhage which gave me cause for alarm. Indeed, a moderate flow of blood seems to act beneficially, by relieving the engorged condition of the remaining portions of the mucous membrane. When the hypertrophy is seated anteriorly on the bones or septum it can be snared by previously transfixing with a glover's needle, as suggested by Jarvis,[60] or, better, by using the electric cautery. The hypertrophies over the posterior half of the septum are more difficult to deal with, and in these cases I believe the galvano-cautery preferable to the snare. In a tractable patient the mass may be transfixed and snared; but I generally resort to one of the other methods which have been given above.*

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* In one case permanent relief was obtained by linear [illegible] sions of the mass with a bistoury, followed by dilatation with [illegible] gies, which act not only as dilators but also [illegible] hæmorrhage which follows the incisions. In this connection I [illegible] that I have resorted *to incision of the turbinated [illegible]*, and invariably with great and immediate relief. A [illegible] of the erectile cells is thus effected and the [illegible] that affection is diminished. This method of [illegible] ies for the relief of coryza, headache, etc., [illegible] in the Transactions of the Medico-Chirurgical Faculty of Maryland for 1883. It has since been used with success by [illegible] (Nasal Catarrh, etc., Philadelphia, 1884), and Glasgow (Trans. American Laryngological Association, 1888).

The after-treatment consists in spraying the nostrils with a soothing, disinfectant, and detergent spray. The one I commonly employ is a weak solution of carbolic acid in oil of sweet almonds. A cotton respirator should be worn in the nostrils for a day or two after the operation to avoid the irritation of the floating particles of dust in the atmosphere. The patient may be directed to saturate a plug of absorbent cotton with the solution and pass it into the nostril once or twice a day until cicatrization is complete.

I have never seen the disagreeable after-effects here apply follow the operation with the galvano-cautery. One patient complained of pain in the infraorbital region for one or two days after the removal of an anterior hypertrophy; but it was very questionable whether this was due to the operation, as he had been for a long time subject to neuralgic pains in the course of the trifacial nerve. Rapid cicatrization and disappearance of complications has been the invariable rule in all cases where I have performed the operation.

The amount of hæmorrhage will vary with the time occupied in the ecrasement, with the age and vascularity of the mass. The slower the traction, the less profuse the hæmorrhage. As a rule, the cleaner, whiter, and older the hypertrophy, the less abundant the bleeding. To avoid hæmorrhage, it has been advised (Bosworth) to tighten the loop slowly, giving one-half turn of the screw every five or ten minutes, consuming at least two, or better, three hours in the operation. I have never found such a procedure necessary. When the operation is quickly performed, a gush of blood follows the removal of the mass, and the nose continues to bleed until the engorged vascular spaces of the erectile tissue have been depleted. The hæmorrhage then ceases in many cases spontaneously. Secondary *hæmorrhage* sometimes occurs, and generally takes place from six to twelve hours after the operation. It is never profuse, and can be readily checked by the patient himself.

In many instances, if the instrument be gently and skilfully introduced, and the facial contortion and straining of the patient be controlled, the snaring of the hypertrophy is quite painless. If the mass be slowly severed, very little pain is felt—sometimes none at all. I have several times removed the growth without the patient's being aware of the performance of the operation. When the nostril is very tortuous, or when hypertrophy of the turbinated bodies coexists with a deflected or irregularly thickened septum, the introduction of the snare is sometimes painful, the amount of pain depending upon the altered relations of the parts, the degree of hyperæsthesia of the mucous membrane, and the curve and diameter of the wire loop. The pain may be diminished, however, by hypodermatic injections of morphine or an anæsthetic spray. In the compression of the mass, pain is occasionally referred to various points in the distribution of the fifth nerve. Various other reflex phenomena sometimes occur during the operation, such as cough, pain in the ear and larynx, movements of deglutition, etc.

The advantages which may be claimed for this operation, apart from its comparative painlessness and simplicity, may be briefly summed up as follows:

(1) It fulfils in the simplest and most radical manner the chief and absolute indication in the treatment of hypertrophic nasal catarrh, viz., the removal of the obstruction.

(2) It restores the respiratory current to its normal channels, thereby avoiding the irreparable injury with which the organs of respiration, vocalization, audition, and olfaction are necessarily threatened.

(3) It removes one of the most prolific sources of the discharge in nasal catarrh, and favors the return of the mucous membrane to its normal state.

(4) In the majority of instances it causes the various complications, and especially those of reflex character, to disappear.

(5) By the depletion of the cavernous cells of the turbinated bodies it exercises a beneficial effect upon the whole area occupied by the erectile tissue.

The second indication is best accomplished with a detergent alkaline spray. Carbolic acid, borax, benzoic acid, the bicarbonate, phosphate, and sulpho-carbolate of soda, alone or in combination, are the medicaments commonly employed. By means of the compressed-air cylinder the nasal cavities can be thoroughly cleansed and the crusts removed with facility. If a sufficiently powerful spray be not available, the latter should be carefully brought away, a probe wrapped with absorbent cotton and dipped into vaseline, cosmoline, or some such substance being used for the purpose. Sometimes thick shreds of mucus are found in the Eustachian tubes and the fossæ of Rosenmüller, which cannot be dislodged by the spray, and which must be removed with the cotton-carrier or forceps. The cleansing of the nose is of the utmost importance. It should be ascertained by inspection that the parts are clean before applying alteratives or other remedies to the nose. It is useless to apply them to inspissated mucus. The continuous use of alkaline and sulphur waters is sometimes productive of decided benefit in diminishing the secretion.

The astringent or alterative to be used will depend upon the character of the inflammation and upon the susceptibilities of the patient. It is better, as a rule, to change the remedy from time to time until one is found which accomplishes the maximum of good. One of the simplest and best is common alcohol, diluted according to circumstances. Weak solutions of bichloride of mercury, as recommended by me elsewhere,[11] are often of decided benefit. For post-nasal and pharyngeal inflammation I have also used the *tincture of galanga* with excellent results. Galanga is an Indian remedy for catarrh, whose powdered root has been recommended (Bosworth) in the form of snuff. It will be found, however, exceedingly difficult to reduce the root to an impalpable powder, and even when mixed with other powders it is irritating and often produces attacks of acute coryza. To obviate this, I have had an alcoholic tincture of the root, diluted according to circumstances, prepared for use as a spray behind the soft palate. This has an aromatic, not unpleasant odor, and produces a sharp, pungent, peppery sensation, which subsides, however, almost instantaneously, and generally affords immediate relief. The application leaves an agreeable astringent sensation in the throat, which lasts for some time, and is not open to the evil results which follow the use of nitrate of silver and similar substances in that locality.

The use of powders in the nose will often do more harm than good, unless the substance be reduced to an impalpable state. Their indiscriminate use is to be discouraged, especially where the parts cannot be thoroughly and repeatedly inspected. Otherwise they will form a thick paste with the discharge, whose removal they mechanically impede, or, collecting in the crevices of the nasal chamber, lay the foundation for crust formation, or act as foreign bodies. It is much better to apply the remedy to the mucous membrane in some such vehicle as glycerine, gelatine, cosmoline, vaseline, etc. This should not be thrust blindly into the nose, but the nostril should be dilated and the application made directly to the diseased surface. Where excoriations or ulcerations of the nostril exist, I have found that the powder of calendula dusted over the raw surfaces, or applied as a glycerole, will cause rapid healing and diminution of the discharge. I have also found the combination of this drug with boracic acid, as recommended by Dr. Sexton,[12] of New York, as ointment, of considerable value in purulent cases of catarrh of the nose.

During inclement weather, and when exposed to a vitiated atmosphere, the nasal chambers should be protected by means of a respirator. Those in common use are ungainly objects, against which personal vanity and æsthetic taste alike rebel. Few patients, especially ladies, will submit to being muzzled with these unsightly appliances, which, besides detracting to a great extent their personal charms, are in the eyes of their fellow-man the outward and visible suggestion of chronic nasal catarrh. When the discharge is not very profuse, absorbent cotton, medicated or not according to circumstances, may be substituted for the ordinary respirator. A small piece of cotton is taken and its fibres teazed gently apart with the fingers. It is then folded lightly upon itself and introduced into the nostril just beyond the orifice of the anterior nares. If care be taken to separate the fibres sufficiently loosely, respiration can take place with ease. This simple expedient will be found of considerable value to mitigate the severity of the atmosphere and to equalize the temperature within the nasal chamber.

The cotton respirator should not be confounded with the plugs in common use to medicate and give support to the inflamed nasal membrane. The use of tents of various kinds as a means of conveying remedies to the cavities of the nose is of very ancient origin, and it is therefore amusing to read the altercations in which some surgeons of the present day have indulged as to the priority of their introduction in the treatment of nasal inflammation. Where the discharge is profuse, or when caries or necrosis of the bones is present, I can strongly recommend *oakum* as a substitute for the cotton tents commonly employed.

In addition to local applications, attention should be given to the general health, which is often seriously impaired. The existence of diathetic diseases should be carefully sought for, and the different organs and their functions systematically interrogated.

The principal measures for the treatment of the third stage of chronic catarrhal inflammation of the nasal passages, have already been given in detail in the article on Ozæna. The principal points to be attended to are (1) the utmost cleanliness of the nasal passages, (2) the dissipation of the odor, and (3) the stimulation of the healthy mucous membrane to vicarious activity. As a disinfectant I have found nothing better than the bichloride of mercury. This may be used topically in solution, or the local application may be assisted by the administration of small tonic doses of mercury internally.

It would carry me far beyond the limits of the space allotted to this article to consider the hygiene of the upper respiratory organs ; but a few general remarks upon certain all-important subjects may, perhaps, be not out of place. A catarrhal patient should not be deprived of all the luxuries of life, severed from all legitimate pleasures, or driven to the verge of inquisitorial torture by an enforced system of coddling and a perpetual dread of the variations of the thermometer, nor be taught to rush indoors whenever a cloud passes over the sun. He should live as much as possible in the open air and indulge in systematic exercise, according to his individual endurance. The skin should be kept in a healthy and active condition by daily cold baths, frictions, etc. As little liquid nourishment should be taken as is compatible with the comfort of the individual. The ingestion of large quantities of liquid, especially in the form of alcohol, is greatly to be deprecated. It is surprising what an effect the combination of exercise and abstention from a superabundance of fluid often has upon the course of a catarrhal inflammation. I have known it to check the secretion when all other means had failed. To sum up, the patient should exercise a sufficient amount of common sense and discretion in matters included under the commonly recognized conception of "taking care of one's self," and live as much as possible under the guidance of the common law of health.

In the preceding pages, and in the article on Chronic Laryngitis, in Vol. IV. of this HANDBOOK, I have endeavored to give a general idea of the principles which should govern the physician in the treatment of chronic catarrhal inflammation of the upper respiratory tract. To enter into detail either in the matter of methods or the comparative merits of drugs would be impossible within the contracted sphere of the present communication. Each case must be studied by itself. Indeed, in all cases, the search for the cause should be the study of the individual and the complex forces by which he is influenced and surrounded ; and upon the correct interpretation of these, more than upon mere inspection of the local malady, will often rest a rational diagnosis and a successful mode of treatment.

John Noland Mackenzie.

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[1] Beweis dass die Eingeführten Meinungen von den Catarrhen oder sogenannter Haupt-Steckflüssen nicht bessern Grund als alte Weiber Mährchen haben, etc. Nürnberg, 1691.

[2] De Methodo Medendi, lib. ii., cap. viii. De olfactus nariumque affectibus. Venetiis, 1554.

[3] Ab Altomari, De medendis humani corporis malis ars medica, cap. xxxix., ed. Lugd., 1559.

[4] De Polypo Narium, memb. ii., cap. i., § 1. Lipsiæ, 1672.

[5] Opera omnia med.-physica. Tom. I., inst. med. phys., cap. xiv., thesis 4. p. 28. Lugd., 1690.

[6] Pathology of the Membrane of the Larynx and Bronchi. Edinburgh, 1809.

[7] Mediate Auscultation and Diseases of the Chest, English translation, 1846, p. 60.

[8] Recherches sur le tissu muqueux ou l'organe cellulaire, et sur quelques maladies de la poitrine. Paris, 1791.

[9] Ueber den Zusammenhang der Katarrh. Rheumatismen und der Acuten Exantheme. Würzburg, 1830.

[10] See Fuchs, Lehrbuch der Spec. Nosologie u. Therapie, Bd. i., S. s. Göttingen, 1845.

[11] Die Krankheitsfamilie Rheuma., Bd. I., p. 189. Erlangen, 1841.

[12] Die Pathologie u. Therapie der Rheumatosen in Genere., p. 42 u. 109. Würzburg, 1860.

[13] Die Spec. Pathologie u. Therapie, etc., Bd. iii., 1 Abth., S. 610. Erlangen, 1843.

[14] Memoire lu à la Soc. de Méd. de Bâle, October, 1850, p. 5. Geneve, 1851.

[15] Katarrh u. Influenza. München, 1865.

[16] Post-Nasal Catarrh, etc., Philadelphia ed., 1884.

[17] De morbis capitis, lib. ii., p. 1067. Quoted also by Hagens, loc. cit.

[18] De Sialogog. hist. med., iv., p. 172. Dresden, 1723.

[19] Ephem. nat. cur. dec. ann., vii. et viii., Obs. cxcv. De ozæna in quatuor fratribus.

[20] Medical News, October 24, 1885.

[21] See Friedreich, Virchow's Handbuch, Bd. v., S. 398, Erlangen, 1858, and Hiller, Untersuchungen uber die Contagiosität purulenter Secrete. Diss., Berlin, 1871.

[22] Adv. anat. 6 in calc. explic. tab. 2 in Decemb. n. 2. De sedibus et causis morborum. Epist. xiv., cap. 16 in fin.

[23] Die Krankheiten der Nasenhohle, etc., S. 78. Berlin, 1876.

[24] Virchow's Archiv, Bd. lxxv., S. 45, 1879.

[25] Ibid., 1881, Heft 2. 1881 (separat Abdruck).

[26] Normale u. pathologische Anatomie der Nasenhohle, etc. Wien, 1882.

[27] Loc. cit., and Archives of Laryngology, vol. iii., p. 236. 1882.

[28] Anthropologia, book ii., chap. 10. London. Third edition, 1727-8.

[29] De naturâ et necessitate spiritus animalis et de succo nervoso. In the Bibliotheca Anatomica of Mangetus.

[30] Diss. inaugural. de cavitatibus ossium capitis, etc. In 8th Book of Haller's Dissertations. For the references to the works of Vieussens and Reiniger, I am indebted to Zuckerkandl.

[31] Die Krankheiten der Nasenhohle. Berlin, 1876.

[32] Aerztlich. Correspondenzblatt für Bohmen, 1874. Nos. 23 and 24, 1875, and No. 24, 1877.

[33] Transactions of the Seventh International Congress ; also in various current periodicals.

[34] Virchow's Archiv, vol. lxxxvii., p. 285 et seq., 1882.

[35] Vide Christison, Treatise on Poisons ; Bell's Medical Lib., Phila., 1845, p. 385 ; and Ducatel, Balto. Medical and Surgical Journal and Review, 1833, vol. i., p. 44.

[36] De Nonnullis Chromii Præparatis. Diss. Inaug. Toxicolog., etc. Vratisl., 1837 (Resume in the Med. Zeitung, Berlin, 1838, Nos. 24 and 25).

[37] Mem. sur les Accidents qui atteignent les Ouvriers qui travaillent le Bichromate de Potasse. Annales d'Hygiene Publique, etc., 2me s., tome 20, p. 83. Paris, 1863.

[38] Mem. sur les Accid. auxquels sont soumis les Ouvriers, etc. Paris, 1869. Baillière et Fils.

[39] Contribution à l'Étude de l'Acide chromique, etc. These de Paris, 1878, p. 64.

[40] Annales des Maladies de l'Oreille, du Larynx, etc., 1884, and the Journal of the American Medical Association, November 29, 1884.

[41] Transactions of the Amer. Laryngological Association, 1885, p. 98.

[42] Monatsschrift für Ohrenheilkunde, etc., Nos. 2 to 5, 1883.

[43] Aerztliches Correspondenzblatt für Bohmen, No. 24, p. 23, 1875.

[44] On the Forms of Nasal Dyspnœa, see also Article on Nose, Neuroses of the, REFERENCE HANDBOOK, Vol. V.

[45] Transactions of Amer. Ophthal. Soc., 1883.

[46] The Medical News, September 6, 1884.

[47] From a paper read by title before the American Laryngological Association, June 25, 1885. See also letter in Philadelphia Medical News, May 30, 1885, on Isolation of Temperature Sense.

[48] Diseases of the Nose, p. 81-82. New York, 1884.

[49] Archives of Laryngology, January, 1883.

[50] Nasal Catarrh, etc., pp. 115-16. New York, 1885.

[51] Boston Med. and Surg. Journ., April 29, 1875.

[52] Archives of Laryngology, April, 1881.

[53] Ueber die allg. Verwendbarkeit der kalten Drahtschlinge, etc. Prag, 1878.

[54] Quoted by Morell Mackenzie, Arch. Laryngology, April, 1882.

[55] On the Literature of the Ligature and Snare, *vide* Levret, Observations sur la cure radicale de plusieurs polypes, etc., Paris, 1749 ; Velpeau (Operative Surgery, vol. iii., Am. ed., N. Y., 1847, pp. 149 and 411), M. Mackenzie, loc. cit.).

[56] Ueber die allg. Verwendbarkeit, etc., S. 19.

[57] Loc. cit.

[58] New York Medical Record, July 9, 1881.

[59] Ibid., 1875, p. 785.

[60] Archives of Laryngology, October, 1882.

[61] Maryland Medical Journal, February 15, 1883.

[62] New York Medical Record, December 31, 1881.

EAR, SYPHILITIC AFFECTIONS OF THE. I. ACQUIRED SYPHILIS.—AURICLE.—*Primary syphilitic chancres* have been but very seldom seen on the auricle and the adjacent parts. Desprès[1] found among twelve hundred syphilitic patients one with a chancre (?) on the auricle. Pellizzari[2] reports having seen a primary sore on the lobule, and thinks that it was caused by the use of a razor, which the son of this patient had previously used in shaving a sore on his penis. Hepner[3] saw a chancre on the lobule of a woman's ear, which resulted from a kiss by her infected husband. The same author[4] saw also, in the clinic of Dr. Fournier, in Paris, a phagedænic hard chancre on the lobe and the posterior part of the lower third of the auricle, caused by the bite from an infected individual. A similar case due to a bite has been observed also by Hutchison.[5] Hulot[6] saw a chancre on the base of the tragus, the origin of which was problematical. Zucker[7] has described at length the history of a case of chancre on the outer surface of the tragus. A chancre on the mastoid process in a man, due to the kiss of a prostitute, has been observed by Mracek,[8] and another in the same place in a child, caused by infection from the nurse, has been described by Hulot.[9] Finally, Lancereaux,[10] speaking of otitis syphilitica externa, says that it attacks sometimes the auricle, at other times the external canal, or it may attack both parts simultaneously, and that it manifests itself usually in the form of a chancre.

As far as can be seen from the description of the cases here cited, the chancres presented the usual appearance; the lymphatic glands in the vicinity were enlarged and indurated. In Zucker's case the tragus was of a livid red color, of twice the normal thickness, and on its anterior surface was a pigmented radiating cicatrix. The entire parotid region was involved in the process; it was greatly swollen, felt as hard as a board, but was not at all painful. There was no secretion from the external canal, and the hearing was but slightly diminished in acuteness. In this case the diagnosis of primary syphilitic infection was facilitated by the recent appearance on the surface of each hand of three or four small, round, slightly scaly efflorescences. The genitals were intact, and the inguinal glands were not swollen. A course of inunctions produced a perfect and rapid cure.

A primary sore on the auricle may be mistaken for cancer, from which it differs, however, in that it presents a clean surface and secretes but little. The nearest lymphatic glands usually enlarge with the development of induration in the primary sore.

Secondary and Tertiary Forms.—Manifestations of constitutional syphilis are not very rarely observed in the auricle. Squamous, pustular, and papular eruptions, usually in connection with the same affection on the integument of adjacent parts, but sometimes limited to the auricle and external canal, have been seen by many writers. According to Gruber[11] papular eruptions are most frequently seated at the point of insertion of the auricle, while exanthematous eruptions appear mostly on the other parts of the auricle. Broad condylomata have been often seen by Desprès on the lobule, and usually in the hole for the earring. Wilde,[12] as far as I know, is the only author who maintains that syphilitic ulceration is by no means uncommon, and that rupia is frequently seated on the external ear.

Tubercular syphilides* and gummata of the auricle have been observed by Zeissl,[13] Burnett,[14] Buck,[15] Field,[16] Hessler,[17] Politzer,[18] Sexton,[19] Pierce,[20] Ravogli,[21] Weekes,[22] Barclay,[23] Bumstead and Taylor,[24] and McBride.[25] In all of the cases reported the affection appeared in the so-called tertiary stage of syphilis. In almost all only one ear was affected, and in the majority of the cases no other symptom of syphilis was present at the time the patient came under observation. The seat of the tubercle or gumma was in the anterior part of the auricle in all the cases, except Burnett's, in which it occupied the posterior surface. A case with symmetrical patches of lupus erythematosus in the concha of each ear, probably syphilitic, was seen by Hutchinson (l. c., page 148). According to Zeissl, the auricle may be the seat of both the dry (non-ulcerating) and the ulcerating forms of gummata, and the latter frequently shows a tendency to the lupoid character in this situation (Fournier). In Burnett's case, which is about the only one recorded in which the disease was seen in its earliest stages, there first appeared a circumscribed infiltrated lump on the posterior surface of the auricle, and this gradually extended until it had diffused itself throughout the tissue of the pinna. It was slightly elevated above the general surface of the auricle, of a deep reddish color, painless, and was not attended with itching; it was inclined to run a slow course. In the space of a month or six weeks the infiltration had diffused itself throughout the greater part of the auricle, and somewhat over the mastoid portion. The thickening and deformity of the auricle had become considerable, the groove behind the auricle was obliterated, and the appendages assumed a firm, thick feeling. This condition lasted for some weeks, then softening and ulceration ensued, the latter beginning in some natural groove or depression. The ulceration formed by the breaking down of the gumma may assume any shape, and if not properly treated, soon increases in size and depth. The floor of the ulcer is usually ragged and covered with dirty grayish matter which cannot be readily removed. The discharge from the ulcer is often excessively offensive. In several of the reported cases, necrosis of parts of the auricular cartilage, and exfoliation of the sequestra occurred, and in Field's case two-thirds of the auricle was destroyed. As a rule, comparatively little deformity seems to result from this affection, sometimes even when the infiltration is extensive and the ulcer large and deep; very often an indelible, depressed white scar is in after-years the only evidence remaining of the gumma. In Barclay's case, in which the cartilage of the concha, tragus, and canal was exfoliated, the general outline of the ear remained normal. The first abnormality to strike the attention was the peculiar deformity of the concha, the upper and lower limits of which were preserved, while the tragus and meatus were absent. The beginning of the helix above was at an oval pit in the concha, and the intertragal notch below was a circular pit. There was a shining, bulging, yellowish spot—resembling somewhat a sebaceous cyst—right over the site of the normal meatus, upon a strong band of cicatricial tissue, extending downward and backward from a spot above and in front of the site of the normal tragus, which band completely closed the meatus. Except a slight tightening of the skin, a seeming loss of subcutaneous tissue on the anterior side, and a slight drawing outward and forward of the auricle, it was otherwise apparently normal. Above and anterior to the site of the normal tragus, and near that of the temporo-maxillary articulation, was a stellate cicatrix.

The diagnosis of the diseases under consideration, as well as of those which I shall treat farther on, must rest largely on the previous history of the case. If syphilitic infection is denied, and nodes of or gummata on the bones are absent, careful search should be made for scars and marks left by secondary affections of the skin and mucous membranes. An ulcerated tubercle may possibly be confounded with lupus vulgaris and scrofulous ulcer. In both of the last-named affections there is, however, very frequently considerable redness and œdema of the skin around the ulcer, while the syphilitic ulcer is, in most instances, sharply bounded by healthy tissue skin. Lupus vulgaris begins, moreover, usually before puberty; its course is much more chronic, and there is but little discharge from the ulcer.

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* The tuberculo-syphilide is a [illegible]

From an ulcerating epithelioma * the syphilitic ulcer can generally be distinguished by the absence of enlarged glands in the neighborhood, and by the more offensive odor of the discharge.

The *treatment* of these affections does not differ from that of tertiary manifestations in other parts of the body. Iodide of potassium, alone or combined with mercury, will cure these cases.

Local treatment alone was of no avail in any one of the cases reported.

External Auditory Canal.—This part of the ear is not very rarely the seat of *Broad Condylomata* (*Mucous Warts*) and of ulcers in persons suffering from constitutional syphilis. The occurrence of the condylomata of the external canal is mentioned by Moos and by Troeltsch; but for the first full description of this affection and its treatment we are indebted to Stöhr,[25] who had the opportunity of seeing fourteen cases of this disease in about three years. Wilde's (loc. cit., 222) case, published nearly twenty years before Stöhr's paper appeared, may, as Knapp suggests, have been also one of syphilitic origin; but Wilde who, throughout his book, shows that he was familiar with the manifestations of syphilis in the ear, says expressly that the patient was otherwise healthy, and attributed her affection to cold.

Since Stöhr's publication broad condylomata have been observed and described by Buck,[15] Knapp,[26] Christinneck,[27] Noquet,[28] Zucker,[7] Purjesz,[29] Felici,[30] Trautmann,[31] Kochner.[32] Desprès[1] found among 1,200 syphilitic patients (980 of whom had condylomata in various places), 5 cases of condylomata of the external canal; while Ravogli was unable to find a single case of condylomata of the external canal in 144 syphilitic individuals (77 of these had condylomata in other parts of the body) whose ears he had examined. Buck saw but 2 cases in 3,976 ear patients; Knapp met with only 1 case in from 9,000 to 10,000 ear cases; and the writer of this has seen but 2 cases out of about sixteen thousand ear patients. Analyzed with regard to the sex, the published cases show a preponderance among the females. In most cases but one ear was affected. As a rule, condylomata of the external canal appear early in constitutional syphilis, while other skin eruptions, ulcerated papulæ on the fauces, and glandular swellings are present. In most cases purulent inflammation of the middle ear, sometimes of long standing, precedes the development of the growth. Condylomata begin as broad, slightly raised papulæ, the surface of which at first is dry, but soon becomes moist. The papulæ gradually grow in size, and when situated close to each other they coalesce into large patches. These are often subdivided by rhagades. In most cases the upper surface of the excrescence, which is at first smooth and somewhat convex, becomes ulcerated and secretes a sero-purulent fluid, which often causes inflammation and ulceration of the adjacent parts free from these growths. If ulceration does not occur, the epidermis covering the excrescence becomes thickened, whitish, and granular. These growths often occur in great numbers in all parts of the canal, and may even be seated on the drum-membrane. Sometimes they not only fill the canal, but also protrude out of the external meatus. The excrescences are at first painless, but after ulceration has occurred they often cause severe pain, which is increased by movement of the jaw. More or less impairment of hearing and tinnitus usually result from the obstruction of the canal, and occasionally a purulent inflammation of the middle ear is developed subsequent to the appearance of the warts. In one of Buck's cases (*American Journal of Otology*, i., page 26), a man, aged twenty-eight, who had had otorrhœa for seven months before, but whose hearing was not impaired, the orifice of the meatus was found almost completely obliterated by the presence of an elevated patch of what seemed at first granulating tissue. The dividing line between this patch, which completely encircled the orifice and the healthy skin of the auricle, was sharply drawn, the edges of the elevated portion being quite abrupt. In Knapp's case, the condylomata developed a few months after infection, and when the patient came under his observation, six months after he had contracted syphilis, he found the ear canals filled, and the external orifice of the meatus and the adjacent parts of the concha occupied all around, by reddish, wart-like excrescences resembling the syphilitic condylomatous growths so often seen at the anus. Some of these were ulcerated at their apices and discharged a thin, watery fluid. A papular syphilide covered the whole body, and was very marked on the forehead. In the soft palate there were ulcers with unclean bottom and raised concave edges. The glands of the neck were swollen, and the patient was very pale and weak. During the first weeks of treatment, however, there was an aggravation of the affection of the pharynx. She suffered intense pain in the ears, and was relieved when profuse purulent discharge from the ear set in. The walls of the ear canals were so much swollen that no speculum could be introduced; yet the characteristic whistling sound on inflation showed that both drum-heads were broken. The case recovered fully under antisyphilitic treatment.

The diagnosis of broad condylomata of the external canal can usually be made without difficulty, as manifestations of secondary syphilis are almost always present in other parts of the body at the same time.

The prognosis is favorable. Under constitutional antisyphilitic treatment and the local applications to be mentioned, the excrescences usually shrink rapidly, and eventually disappear entirely. Depressed cicatrices, destitute of hair, sometimes remain, but permanent contraction of the canal very rarely follows this affection.

Constitutional treatment alone will in most cases cause the condylomata to disappear. But if they occlude the canal and cause retention of the discharge from the tympanic cavity, they may be abscised or carefully cauterized with nitrate of silver in substance. Thorough cleansing of the canal with warm salt water, and inflation of the middle ear should also be practised if suppuration of the middle ear is present. In some cases benefit was apparently derived from dusting iodoform or calomel on the excrescence, or washing the same with a one per cent. solution of nitrate of silver.

Syphilitic ulcers of the external canal seem to have been observed by some of the older writers, as Bell, in his work on Lues, speaks of deafness produced by a "scruffy" eruption, and sometimes ulceration of the external auditory passage, occurring as a consequence of that disease. Referring to these Wilde says: "But the description is not sufficiently accurate to be depended upon, and has not been confirmed by subsequent observers. No doubt, cutaneous syphilitic disease will extend by ordinary continuity of surface into the meatus, but as a special form I am unacquainted with it" (loc. cit., p. 198). Since Wilde's time such ulcers have, however, been frequently observed, and have been studied especially by [illegible]. According to this author they are usually circular in form and covered by a dirty, grayish-white exudation. Their edges are usually greatly swollen, and may thus cause considerable diminution of the calibre of the canal. They were seated in the outer part of the canal up to the point of union of the cartilaginous and osseous portions, and were found in one or both ears. He saw these ulcers in ears with normal membranæ and healthy middle ears, but in most cases they were associated with chronic purulent inflammation of the middle ear and perforation of the drum-membrane. The glands in the vicinity of the ear were always much swollen in these cases, and other manifestations of constitutional disease were never wanting. The treatment recommended by this author is energetic cauterization with nitrate of silver in substance, which, though painful, may be relied upon to heal the ulcer. Hinton has also seen secondary syphilitic ulceration of the meatus, mostly in the form of a narrow, [illegible] ulcer at the orifice, attended with an [illegible] discharge and general inflammation and swelling of the passage. The appearance and history sufficiently mark its character, and in the cases Hinton saw, iodide of potassium and black wash brought about a cure. A case of this kind has been described by Buck. The patient had acute purulent inflammation of the middle ear, with perforation of the drum-membrane. The ulcer occupied the lower wall of the outer half of the canal and extended outward upon the auricle. The limits of the ulcer were well defined. The chancre had appeared one year before, and there was also syphilitic pharyngitis.

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* *Differential Diagnosis between Ulcer, Tubercle, and Cancer.*—Hutchison (loc. cit., p. 511), speaking of the differential diagnosis between cancer and syphilis, says: "I am most anxious to insist on its extreme difficulty. The surgeon who trusts to rules, or who ventures to rely with confidence on his own powers of observation as regards minute differences of appearance between cancerous and syphilitic ulcers, will often make serious mistakes. Cancerous processes may be simulated by syphilis in the closest possible manner. As a general rule, it may be said that we distinguish between a cancerous ulcer and one that is syphilitic by observing that in the former a process of growth precedes that of ulceration, whereas in syphilis it is at best only one of chronic inflammation. Without doubt this is a most important distinction. In syphilis the edges of an ulcer may be greatly indurated and its base may be firm, but there are seldom any sprouting masses on the surface, or any well-defined margins to the induration, such as we encounter in cancer. Exceptions, however, occur even to this statement, and now and then even a syphilitic sore may be covered with bossy masses of firm granulation structure which closely resemble epithelioma. I possess more than one drawing in which the ordinary features of rodent ulcer, its clean surface, and its sinuous, rolled edge of induration, were so exactly imitated by tertiary syphilitic sores that we had to appeal to treatment for diagnosis. I have not attached much importance, for diagnostic purposes, between syphilis and cancer, on the presence or absence of implication of lymphatic glands. Nothing can be more illusory than to teach that enlargement of the lymphatic glands is one of the *features* by which cancer can be distinguished from other local disease. There is, no doubt, however, that in any case which comes under observation late, and with enlargement of the glands already existing, we may take this part as important evidence in support of the diagnosis of cancer. Neither in secondary nor tertiary syphilitic lesion is it at all common for there to be any implication of lymphatics." "In very obscure cases the aid of the microscope should be invoked, and if this should fail to give positive evidence one way or the other, the patient should be given the benefit of the doubt and be put under antisyphilitic treatment. In cases in which it is desired to use treatment as a means of diagnosis, the best plan will usually be to rub in mercury pretty freely, and to give iodide of potassium by the mouth at the same time. Under this plan any growth or ulcer of syphilitic origin ought within a week or ten days to change its features in an unmistakable manner."

Politzer has observed two cases of this description. In one, with chronic purulent inflammation of the middle ear, the ulcer occupied the lower lateral wall of the cartilaginous portion. Syphilitic ulcers of the pharynx were present at the same time. In the other, the ulcer extended along the entire length of the cartilaginous portion, and a second ulcer with everted edges occupied the concha.

In a case reported by Jacobson the patient had been affected, up to within a few months before he came under observation, with chronic suppuration of the middle ear. He was suffering intense pain in the head, and had other symptoms of cerebral irritation. He had contracted syphilis six months before and had ulcers on the [illegible] at the time. The ulcer, which was seated at the entrance of the right external canal, was of the form of a ring; its floor was covered with an adherent, dirty, whitish-gray exudation, and its margin was much swollen. It was very sensitive to the slightest touch, and the tragus and mastoid process were tender on pressure.

Diagnosis.—Non-specific ulcers of the external canal are very rarely seen, except in children with neglected purulent inflammation of the middle ear, and in eczema of the canal in adults, and the presence of an ulcer should therefore always arouse suspicion as to the existence of constitutional syphilis. It seems hardly possible that the opening of a furuncle can be mistaken for ulcer by any one at all familiar with ear affections. In cases of syphilitic ulcer the glands near the ear are always swollen, and other signs of syphilis are never absent.

Diffuse inflammation of the external canal due to syphilis is said by Lancereaux de Lanchère to be of frequent occurrence in the secondary stage. According to this author both auricles are usually attacked simultaneously; there is only moderate swelling, the skin is red and swollen, and the discharge is very offensive. But McBride appears to be the only other author who has seen such a case, and in his there was no disagreeable odor. If we exclude the cases in which papules or condylomata are present, the secretion from which causes inflammation of the lining of the parts of the external canal free from them, instances of diffuse inflammation of this part are doubtless very rare in syphilitic persons. The writer of this article has seen but a single case of this kind, and this occurred many years after infection, and was associated with non-purulent inflammation of the middle ear, and caries of the superior maxillary and palate bones of the same side. In this case the walls of the osseous part of the canal were very red and somewhat swollen. The pain was very great, and not much relieved by repeated deep and long incisions, which at no time liberated pus. The walls were at no time covered by exudation, and there was but little secretion from them. The drum-membrane was but little inflamed, and although it was repeatedly freely incised in the hope of giving exit to supposed pent-up secretion in the tympanic cavity, none escaped. The Eustachian tube was almost impermeable. After much and long-continued suffering the pain subsided eventually while the patient was taking iodide of potassium; complete deafness remained.

The characteristic symptom of syphilitic inflammation of the external canal is said to be very severe pain, even when the swelling is not very great, which is not relieved by the usual remedies, but yields at once to constitutional treatment (Schwabach).

Exostoses of the external canal may, according to Gruber, be caused by syphilis, but nearly all other writers deny that syphilis has anything whatever to do with the production of these growths.

THE DRUM-MEMBRANE.—This part of the ear appears to be but rarely the seat of syphilitic infiltrations and growths. Lang observed a case in which there was a large, pale, glistening papule at the place of the short process of the hammer on a drum-membrane; the membrane itself was very red in its anterior upper quadrant, and slightly opaque throughout. The patient was a woman, with early symptoms of constitutional syphilis.

Condylomata, as we have seen, have been found here in a few cases in which these growths existed also on the walls of the canal.

Baratoux has recorded the case of a woman in whom he found five small gummata on the cheek, in front of the ear; a sixth on the mastoid process; three in the concha and outer part of the external canal; a small, egg-shaped, prominent, faintly opalescent, gummatous tumor on the lower posterior part of the drum-membrane; and a small, round ulcer, covered with a yellowish-white, adherent substance, in front of the handle of the malleus. The gumma on the drum-membrane became ulcerated at its summit in a few days, while the ulcer was cicatrizing.

MIDDLE EAR.—The diseases of the middle ear observed in individuals afflicted with constitutional syphilis do not differ essentially, in their objective and subjective symptoms, from the same diseases occurring in non-syphilitic subjects. Most writers are agreed, however, that the syphilitic forms are characterized by a marked tendency to implication of the labyrinth, or to speak more precisely, by the appearance of symptoms commonly regarded as indicative of disease of the auditory nerve at an unusually early period. The middle-ear disease may present itself in the form of an acute catarrhal inflammation, a chronic catarrhal inflammation, a purulent inflammation, or as a neuralgia of the tympanic cavity.

Acute Catarrhal Inflammation.—This disease is usually, but by no means always, associated with syphilitic disease of the naso-pharyngeal cavity. Frequently but one ear is affected, and in such cases the disease of the pharynx is usually found to be confined to that side. Sometimes this consists of only a superficial erosion. In many cases the ulceration is confined to the posterior wall of the pharynx, behind the velum palati, and, as in this location it rarely causes the patient much inconvenience, it may be overlooked if an examination with the rhinoscopic mirror is omitted.

The subjective and objective symptoms, and the course of syphilitic acute catarrhal inflammation, resemble so closely the idiopathic form that a description of the same seems unnecessary in this place. Schwartze (op. cit., p. 134) asserts that an impairment in the conduction of sound through the bones occurs regularly at an early period in this disease, and adds that it is not known to what this is due. The present writer has, however, seen a number of cases of this affection in which the bone-conduction remained unimpaired throughout.

With regard to the *treatment*, it is only necessary to state that, in addition to the local measures usually employed in the idiopathic form, a course of antisyphilitic remedies will be found necessary to cure the disease of the ear and the pharynx. In this connection it may be well to point out the danger arising from using, on healthy persons, catheters and other instruments that have been employed on syphilitic individuals. Boiling the instruments in a five per cent. solution of carbolic acid may possibly be sufficient to destroy the virus, but in the opinion of the writer it would be far safer to provide each patient with instruments for his exclusive use.

Chronic Aural Catarrh.—With regard to this disease, Wilde (op. cit., p. 254), says: "All the cases I have seen of this affection occurred in young men, and generally those of fair complexion and blue eyes, who had had primary sores upon the genitals from six to twelve months previously, which sores were rather of a deceptive character, so that mercury was seldom given, in the first instance at least, in a legitimate form. Sore throat, papular eruptions, copper-colored blotches, fissures and ulcers of tongue, with loss of strength and slight nocturnal pains, existed previous to the aural affections, which should, I think, be ranked as tertiary symptoms. In almost every case I have witnessed the disease appeared suddenly as an eruption was fading off; in two it came on at a later period and was accompanied by loss of hair; in most it appeared in the upper and middle ranks of life. In some cases there is at first a sensation of fulness in the head, and often vertigo upon stooping or rising up suddenly, but in no instance have I seen it accompanied by acute pain. Tinnitus is not always present." In all of the cases observed by Schwartze, except two, in which the patients positively stated that the disease began with lancinating pain, and in all seen by the writer of this article, the disease was insidious in its approach, and pain in the ear was absent throughout its course. Pain in the bones of the head was, however, occasionally complained of. Tinnitus was present in nearly all the cases, though it was not always very annoying.

As regards the appearance of the drum-membrane Wilde says: "Upon inspection the amount of redness and vascularity will be found much greater than in subacute myringitis, and in this consists one of the chief characteristics of this disease, that while it is unaccompanied by local pain, the membrana tympani will be found to present an amount of redness equal to, and sometimes exceeding, that seen in acute myringitis.* The redness has generally, however, a brownish hue in the syphilitic form. There is not at first much loss of polish, but in a short time the membrane assumes a fuzzy appearance. Both ears are usually attacked at the same time." Schwartze (op. cit., p. 264), Roosa, and most of the more recent writers on this subject, on the other hand, have been unable to find in the appearance of the drum-membrane in this disease anything that could be regarded as pathognomonic of its syphilitic character. Pomeroy[61] believes that it very frequently does not differ in appearance from that in non-syphilitic disease, but that signs of infiltration of the membrane, giving it a greater degree of opacity than would result from a non-specific inflammation, will cause one to suspect constitutional disease. In his opinion the most important aid, however, to diagnosis is the history. Sturgis (*Boston Med. and Surg. Journal*, June 3, 1880) regards the infiltration of the tympanum, conjoined with the absence of vascular congestion, as characteristic of syphilitic catarrh of the middle ear.

The Eustachian tube is usually easily permeable at least by the aid of the catheter. The sounds heard on auscultation are usually dry and broad, but sometimes moist râles are heard. The inflation rarely improves the hearing even for a short time, though it sometimes temporarily arrests the tinnitus. The lining membrane of the pharynx is nearly always hyperæmic, and very often superficial ulcers are found on the arches of the palate and the tonsils. The nose is usually not markedly diseased. The impairment of hearing, which is commonly already well advanced when the patient comes under treatment, in the majority of cases goes rapidly from bad to worse, so that in the course of a few months only loud speech can be heard close to the ear. In the remainder the progress is much slower, and instead of months, years may pass before this state is reached. In a case seen by Schwartze a sudden and great increase in the hardness of hearing followed a blow on the head. In many of the cases, even in persons under thirty years of age, an impairment or loss of bone-conduction occurs at an early stage of the disease, when the tick of the watch is still heard at some distance from the ear. In several of Schwartze's cases even the large tuning-fork C was heard indistinctly or very faintly when placed on the vertex.

Our knowledge of the pathological anatomy of syphilitic catarrhal inflammation is very imperfect, as it must be of all diseases which are not fatal. Moos[38] found in a case of deafness, supposed to have been due to syphilis, beside adhesive inflammation of the labyrinth and the deposit of chalky concretions on the membranous semicircular canals and sacs, inflammatory changes in the drum-membrane, thickening of the pale mucous membrane of the middle ear, and anchylosis of the malleo-incudal joint and of the stapedio-vestibular articulation, all of which have been seen often enough in non-syphilitic cases. In Toynbee's case ("Catalogue of the Museum," No. 512), which occurred in a man about forty-eight years of age, the deafness began five years before death. Right ear: loud voice close to the ear. Left ear: total deafness. The deafness commenced while he had a severe ulceration of the fauces from syphilis. Post mortem.—Right ear: anchylosis of the stapes; the articular surface of os Sylvii much flatter than usual; adhesion between the anvil and hammer; tensor tympani atrophic; membrane of round window thickened; cochlea of a deep-red color. Left ear: anchylosis of stirrup; thickening of membranous vestibule. Schwartze (op. cit., page 135) surmises that the pathological change in the syphilitic cases is a periostitis, and Roosa[39] thinks that this view is correct. The last-named author is also of the opinion that there may be also, in the course of the later periods of the disease, a syphilitic exudation into the tympanum and about the ossicles; and that it may be said, in general, that the syphilitic diathesis seems to cause a more rapid proliferation of tissue, and one that is less amenable to treatment. Sexton,[40] who believes that in the sudden deafness from syphilis (which most other writers on otology of the present day regard as due to disease of some part of the acoustic nerve) the principal lesion is confined to the transmitting structures of the middle ear, says: "As regards the pathology of the syphilitic invasion of the ear, it may be surmised that granuloma, or circumscribed, small, round-cell infiltration, takes place within the tympanum; that the invasion is rapid, and that the conductive apparatus is prevented performing its movements by the particular manner of fixation that occurs. It is doubtful if our present means of pathological study could definitely determine its seat in all cases."

Woakes[41] claims to have seen through the drum-membrane a gummatous exudation in the tympanic cavity.

From what has been said with regard to the symptoms, it must be evident that there is none by which we can positively distinguish chronic catarrhal inflammation of the middle ear, due to syphilis, from that arising from other causes. The supervention of symptoms indicative of disease of some part of the acoustic nerve (impairment or loss of bone-conduction, etc.) in the earlier stages of the disease, occurs unquestionably much more frequently in the syphilitic cases than in others, but is by no means a positive sign of the specific character of the disease. Such symptoms, when present, especially in young and middle-aged persons, should, however, arouse our suspicion as to the presence of syphilis and lead us to make a more careful search for other symptoms of this disease. Only when such are found, or a clear history of constitutional syphilis can be obtained, are we justified in making the diagnosis of syphilitic ear disease.

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* Wilde applies the term myringitis to the disease now generally called acute catarrhal inflammation of the middle ear.

The prognosis of the syphilitic chronic middle-ear catarrh is, on the whole, even less favorable than that of the non-syphilitic form. Nearly every writer has met with some cases in which, under judicious local applications and a thorough course of antisyphilitic remedies, the hearing was improved and even restored. But such cases are, after all, according to the writer's experience, rarely encountered outside of the books. To arrest the progress of the disease is about the most we can hope for.

In the treatment of this disease it will be found necessary, in addition to the usual remedial measures for the ordinary chronic catarrhal inflammation, to resort to constitutional remedies. In all cases in which no doubt exists as to the diagnosis, the patient should be brought rapidly under the influence of mercury by inunctions or injections under the skin, and this should be kept up for a considerable period. Iodide of potassium may be given at the same time. The muriate of pilocarpine, in doses of one-sixth to one-third grain, administered hypodermically, once daily for several weeks, has been of some service in the hands of Politzer, Lucae, and others, in cases complicated with disease of the inner ear.

Purulent Inflammation.—Among the writers on otology much diversity of opinion has always existed as to the occurrence of a syphilitic purulent inflammation of the middle ear. Thus, Frank[44] and Lincke[45] describe an otitis interna, the result of lues. In this form, they say, the inflammation and ulceration extend from the throat and nose to the ear, are accompanied by great pain, and often terminate in suppuration of the middle ear, destruction of the tympanal membrane, and caries of the temporal bone. Wilde (op. cit., p. 252), on the other hand, says that under certain circumstances such a disease may, no doubt, occur, although he himself has never seen such a case and has not met with a well-authenticated instance of it recorded. Kramer[46] doubts that syphilis can cause a specific disease of the ear, and adds that he has never in his own practice, or in that of others, observed such cases, and Erhard[47] is of the same opinion. Virchow[48] mentions, as the result of syphilis, primary purulent inflammation of the tympanic cavity; stricture of the Eustachian tube resulting from cicatricial closure of its pharyngeal mouth, and caries of the temporal bone. In the treatises on diseases of the ear, of more recent date, but little can be found relating to this disease. Politzer (op. cit., p. 530) devotes less than a page to it, and Gruber (op. cit.) merely mentions syphilis as one of the causes of otitis media purulenta. Pritchard,[49] in speaking of the affections of the middle ear caused by syphilis, says that they are of comparatively rare occurrence, and that in some cases suppurative catarrh is set up with perforation, etc. Politzer (op. cit., p. 530) thinks that syphilis may interrupt the progress of the disease toward recovery, and Schwartze (op. cit., p. 176) only says, with regard to this disease, that under the influence of constitutional syphilis the suppuration may become chronic. Troeltsch, Roosa, Burnett, and others make no mention of it whatever. It may also be stated here that the number of cases of this disease reported in the medical journals within the last twenty years is exceedingly small.

Of our present knowledge of this form of otitis media purulenta, it cannot be said that it is much more definite than it was in Kramer's time. Schwartze has seen cases in which syphilitic disease of the bones was absent, but most other writers, including the present, have found such an affection existing in nearly every case. The disease of the naso-pharyngeal cavity may be any one of the various manifestations of constitutional syphilis met with in this locality, or may be a primary chancre due to the accidental inoculation of this part during catheterization of the Eustachian tube. Fortunately such accidents have but very rarely occurred.

With regard to the symptomatology and course of the purulent otitis media, most authors are agreed that they do not differ essentially from the non-syphilitic form. Buck,[50] while not regarding this statement with any great degree of positiveness, owing to the smallness of material which has come under his observation, cannot help feeling that, with increased experience and a closer study of this particular class of cases, we shall in time learn to recognize in these parts textural lesions as distinctly characteristic of syphilis as are most of its external manifestations. In one of the cases reported by him (Case XII.), a second perforation developed in the drum-membrane more than two months after the first, through a melting process similar to that observed so frequently in the velum palati, and he regards this occurrence as totally different from anything that he has ever observed in any case of non-syphilitic inflammation of the middle ear. Probably a similar melting away of a limited area of the drum-membrane took place in another of his cases (Case XI.). In neither of these cases was there any evidence of pressure from within. In the first-mentioned case caries and facial paralysis were subsequently developed, while there was no evidence of interference with the free escape of the pus formed, and this he regards as certainly not in harmony with the ordinary course of non-syphilitic otitis media purulenta. Politzer and others frequently noticed a high degree of deafness in these cases, caused by the frequent simultaneous occurrence of syphilitic disease of the labyrinth. Of the occasional occurrence of condylomata and ulcers in the external canal, in connection with this disease, mention was made in the first part of this article. In the cases observed by the present writer the symptoms were precisely those of the non-syphilitic form, and the course and termination of the disease differed in no way from the other. Ulceration of the mucous membrane, with caries and necrosis of the walls of the tympanic cavity, the mastoid process, and the petrous portion, and facial paralysis, may, according to Politzer, occur under unfavorable circumstances or inappropriate treatment, and end fatally through intracranial affections. Caries has been observed in this form probably no more frequently than in the non-syphilitic forms.

Fatal hæmorrhage from erosion of the internal carotid artery, caused by caries of the canal of the vessel, has been observed in syphilitic as well as in non-syphilitic subjects. Thus we find in the nineteen cases of fatal hæmorrhage collected by Hessler,[51] two in which syphilis was present. One of these cases (reported in full by Jungle in the *Deutsche Klinik*, No. 25, p. 250) occurred in a patient suffering from tertiary syphilis. Two years after he had come under observation he had a sudden profuse hæmorrhage from the left deaf ear, and four months later, after repeated hæmorrhages, the patient died. An autopsy revealed a complete destruction of the interior of the petrous portion of the left temporal bone. The membrana tympani and ossicles were wanting. Of the other case (described by Pilz in his dissertation, "De Arteriæ Carotidis utriusque Ligatura," Berlin, 1868) it is only known that, after severe pain in the region of the right ear, without objective symptoms, a sudden and copious hæmorrhage occurred from this ear; subsequently the blood was mixed with pus. The patient had syphilis, and a fistula on the posterior wall of the pharynx from which pus escaped. After repeated hæmorrhages Billroth first ligated the right and then the left carotid. The patient died under symptoms of anæmia. The autopsy showed extensive caries of the lower wall of the carotid canal, exposing the vessel. The erosion seen in the artery measured 8 mm. in length and 6 mm. in breadth.

Meningitis, iridochoroiditis of the eye on the same side as the purulent middle-ear disease, developed in a syphilitic subject, observed by the writer of this article.[49] In this case the ear disease was arrested and the hearing restored under general treatment alone.

As regards *the diagnosis*, the writer must confess that he knows of no aural symptoms by which the syphilitic form of this disease can be distinguished from the ordinary form. Woakes[41] thinks that the caries due to syphilitic purulent inflammation of the middle ear frequently has this distinguishing feature: the caries is symmetrical, that is, there is a corresponding lesion in both ears. In this disease, as in the diseases previously described, the presence of other symptoms of syphilis can alone decide the diagnosis.

Of *the pathological anatomy* of syphilitic suppuration of the middle ear we know but little. Quite recently Moos and Steinbrügge[50] have had the opportunity to examine both temporal bones of a case of tertiary syphilis. Moos first saw the patient fourteen years before his death. At that time the faucial orifices of the Eustachian tubes were closed by numerous thick, radiating, fibrous bands, so that the ventilation of the drum cavity must have been almost impossible; notwithstanding, there was no demonstrable deviation in the plane of the drum-membrane, in the position of the handle of the hammer, or in the cone of light. Strange to say, the patient never complained of subjective noises nor of dizziness. Bone-conduction was always sufficiently preserved to detect the loud tick of a watch, and the tuning-fork; the capacity for hearing speech was, however, so much reduced that ordinary conversation was not heard beyond one metre. The patient remained under Moos's treatment for about two years, and then passed from under his observation till a week before his death. At this time he was examined by Steinbrügge, who found that he was now only able to hear spoken words in close proximity to the ears; watch of 12 m. normal hearing distance was heard merely on contact in the right ear, and not at all in the left. Tuning-fork A' applied to the forehead was not perceived, applied to the teeth it was heard in the left ear. The otoscopic examination of the right ear revealed a cicatrix in the inferior posterior quadrant of the membrane; the external canal of the left ear contained pus, and there was a round, medium-sized perforation directly under the handle of the malleus. Post mortem, the following conditions were found: Syphilitic caries of the skull and hard palate. Chronic pneumonia. Amyloid degeneration of the spleen, kidneys, and liver. *Right temporal bone:* The greater part of the mastoid process was sclerosed. The mucous lining of the remaining cells was slightly injected. The Eustachian tube (a portion of the pharyngeal orifice was missing) was patent throughout. The tympanum contained a quantity of pus. The mucous membrane was thickened. The drum-membrane was in an atrophic state. The bony roof of the labyrinth was hæmorrhagically infiltrated. *Left temporal bone:* Greasy pus in external canal. Membrana tympani perforated. The mastoid process was sclerosed and of ivory-like hardness. The mucous membrane of the tympanum was very much thickened, and enveloped all structures contained therein. The cavity was filled with a secretion composed of pus-cells and giant-cells. The Eustachian tube (also here a portion of the pharyngeal orifice was wanting) was pervious. *Carotid artery and osseous portion of Eustachian tube:* There was no noticeable change in the outer and inner coats of the artery on either side, not even in that part where the bony partition between the artery and the Eustachian tube measured but 0.087 mm. in thickness. The mucous membrane of the Eustachian canal was normal, but the periosteum of the osseous portion in a medial direction was changed and thickened in a manner to be described below. *Periosteum and bones of middle and internal ear:* In the bony floor of the tympanum and below the cochlea, as well as in the roof of the tympanum, in the bone over the semicircular canals, and in the lateral wall of the osseous portion of the tube, were found markedly dilated medullary spaces, not only enclosing the usual normal contents, but also invariably filled—sometimes more, sometimes less—with larger or smaller groups of cells, enclosing blood-corpuscles, and also with a conglomeration of yellow or yellow brownish pigment. Evidently we had to deal here with the products of a metamorphosis of blood extravasation, the result of rupture of the thin-walled vessels contained in the medullary spaces. In the anterior wall of the bony vestibule, and in the osseous tissue anterior and posterior to the second curve of the Fallopian canal, were noticed several spaces in the bone, varying in size up to 3 mm. in length and 2 mm. in width on the left side, and 2 mm. in length and 1½ mm. in width on the right side. A similar condition was observed in the bone tissue below the first turn of the cochlea on the right side. The cavity here was circular; its diameter measured 2 mm. The contents of these spaces clearly demonstrated two separate stages in the pathological process. In the early stage these spaces were filled with a fibrous net-work, which in several sections showed unmistakable connection with the periosteum of the labyrinthine wall. The meshes of this net-work were filled with vessels more or less numerous, and a small-celled infiltration. The condition demonstrating a later stage, however, mostly predominated. Here the meshes were filled with yellowish coagulated masses, composed to a limited extent of blood-corpuscles and larger round cells, and mainly of fat globules and fatty degenerated cells stained black by the osmic acid. In addition, there were seen in many places, as indications of the earlier stage, the remains of fibres of this net-work in connection with the periosteum of the labyrinth mentioned above.

The condition of the periosteal covering of the promontory on both sides is worthy of special notice. Very much thickened, at places to 0.7 mm., the presence of numerous cavities imparted to it a cavernous appearance. The spaces were here and there lined with a low cylindrical epithelium, and in some places were filled with a tissue composed of fine fibres enclosing coagulated fibrin and fatty-degenerated cells. At first glance these spaces gave the impression of gland tissue; closer examination, however, proved them to be numerous circumscribed foci of inflammatory products undergoing retrogressive changes. The presence of smaller and larger portions of bone, cut off from the main bony mass of the promontory by strangulation of the proliferating periosteum, deserves additional notice. In some portions of the sections these spicula of bone were arranged in rows separated from each other by narrow bands of periosteal tissue. In other parts the proliferating periosteum produced deep indentations in the bone. The periosteum of the canalis pro tensore tympani, and that lining the delicate canaliculi of the plexus tympanicus, presented a similar pathological appearance.

In their comments on the above the authors say that, taking into account the fact that in their case they had to deal not with a fresh gummous neoplasm, but with the later consequences of periosteal proliferation, the above-described changes in the periosteum, with their consequences, would show a close correspondence with the description given by Rindfleisch of syphiloma ossium. Several hæmorrhagic extravasations were found in the perineurium of the tympanic plexus, and these, as well as the proliferation of the periosteum, explained, they thought, the genesis of many of the so-called pure nervous otalgiæ, occurring without objective signs of ear disease in the course of constitutional syphilis. They are also of the opinion that in cases of aural trouble without objective symptoms, occurring in syphilitic subjects, in which the functional examinations pointed to a peripheral disease of the ear, the diagnosis of periostitis of the labyrinthine wall might thereafter be made with a great degree of probability. The attacks of otalgia would serve as an adjunct in making the diagnosis.

The penetration of the proliferating periosteum into the thin, long septum dividing the osseous portion of the tube from the carotid canal, will afford an explanation for those fatal hæmorrhages which occasionally occur in syphilitic subjects, and which are attributable to caries. The observed changes in the floor of the right tympanic cavity invite attention to the possible involvement of the hollow canal [illegible] similar to that of the carotid in the dangerous hemorrhages occurring in tertiary syphilis.

Among other changes found may be mentioned the absence of a not inconsiderable number of fibres of the [illegible] nerve, and [illegible] homogeneous deposits between the fibres of the acoustic nerve; destruction of [illegible] and [illegible] in Rosenthal's canal in the first turn of the cochlea, and hemorrhagic extravasations between the nerves of the membrane of the same; [illegible] of the outer cells of Corti, which may, however, have been due as well to senile retrogression as to a pathological process.

In marked contrast with the great changes found in the above cases was the condition of the structures of the ears in a case observed by Hess, upon which v. Tröltsch made the autopsy. A man thirty-six years of age. Continuous and moderate hardness of hearing since infancy. Eight years before death he contracted syphilis, of which symptoms were still present two years before he died. A few years after infection there was a great increase in the hardness of hearing. During three years of his life he was totally deaf.

Autopsy.—The right ear was free from caries. The left ear revealed otitis media purulenta with kidney-shaped perforation of the drum membrane. The mucous membrane of the tympanic cavity was much thickened and injected. Ulceration of mucous membrane or exposure of bone could not be discovered. The anvil and stirrup were completely preserved and freely movable. There was no caries anywhere. With the exception of a slight thickening of the contents of the vestibule, and unevenness [illegible] of cochlea, the inner ear seemed normal. In his comments on the autopsy v. Tröltsch points out that it does not in the least explain the total deafness, the cause of which must therefore be sought for in the brain.

In the other cases examined after death only such alterations were found as are seen in purulent inflammation of the middle ear in non-syphilitic subjects.

The prognosis is favorable only in the beginning of the ear disease, in the milder cases, and in persons of strong constitution; but when the disease occurs in cachectic individuals, or is complicated with polypi and caries, or the hearing is totally destroyed, the prognosis is very bad. Yet recovery has been observed under antisyphilitic general treatment in cases which seemed hopeless.

The local treatment usually adopted for the non-syphilitic form—thorough and frequent cleansing with warm salt water when the discharge is at all copious; instillation of warm nitrate of silver solution or of alcoholic and watery solutions of corrosive sublimate (as recommended by Burnett), after all pain has ceased; the removal of granulations with the wire snare or with the sharp spoon, etc.—will be found of service as well in the syphilitic form. That in this, as in all syphilitic ear affections, a thorough course of antisyphilitic remedies, perhaps combined with tonics and a generous diet, is as necessary as the local treatment for the ear affection, is the experience of all who have written on the subject.

Neuralgia of the middle ear, due to constitutional syphilis, is an extremely rare disease. Usually syphilitic disease of the [illegible] of the Eustachian tube or of some part of the pharynx or larynx is present at the same time, and is probably the starting-point of the pain in the ear. The entire absence of objective symptoms of disease of the tympanic cavity, and the paroxysmal character of the pain, will establish the diagnosis. Moos, as we have seen, thinks that the hemorrhages in the tensor tympani, the [illegible] of the plexus tympanicus, as well as the [illegible] of the periosteum which he found in one of the cases examined by him, explain to us the grounds of many cases of so-called pure "nervous otalgia," occurring without objective signs of ear disease in the course of constitutional syphilis. The treatment must be directed against the constitutional disease, and if disease of the pharynx or larynx is present, applications to these parts will also be of benefit. Of these, cocaine will probably give greater temporary relief than any other remedy. Schwartze has found of especial use gargles of a solution of the bromide of potassium in such cases.

THE EUSTACHIAN TUBE.—Instances of primary syphilitic sores at or near to the pharyngeal orifice of the Eustachian tube have been observed, according to Politzer, by Ricord, Lancereaux, Desprès, Fournier, Bumstead, Lebouillon, Burnett, and others. J. Solis-Cohen ("Diseases of the Throat," p. 110) says that he has seen a few [illegible] cases of [illegible] from a chancre [illegible] not specially communicated by the infectious use of the Eustachian catheter. Chancres of the naso-pharyngeal cavity are, however, according to all writers, of extremely rare occurrence. The contagion is probably always conveyed through the Eustachian catheter. The sores present no characteristic features. The floor of the chancre is usually indurated, and the lymphatic glands at the angle of the lower jaw are commonly much enlarged. The sore as a rule causes but little pain. Primary chancres of the pharynx, like chancres occurring in other parts, are usually single. The treatment must consist of mercury administered internally or by inunction, and local application of iodoform or iodol; but if the sores prove intractable, they should be touched with the acid nitrate of mercury or other caustics.

Constitutional syphilis rarely causes isolated affections of the Eustachian tube. As a rule, the adjacent mucous membrane is the seat of the same morbid process. The earlier manifestations of syphilis met with in this locality are erythema, mucous patches, and superficial ulceration. The erythema may be generally diffused over the whole mucous membrane, or distributed in irregular patches between which the mucous membrane is of normal color. While not infrequently the syphilitic erythema presents no feature by which it can be positively distinguished from the simple catarrhal inflammation of the mucous membrane, a symmetrical distribution of the erythematous patches is regarded by many authors as strong evidence of the syphilitic nature of the disease. Mucous patches may occur in any part of the naso-pharynx, and have been occasionally observed on the tubal prominence. They present themselves as small, round, slightly elevated patches of a grayish white color, surrounded by a zone of more or less inflamed mucous membrane. Ulcers are comparatively seldom found in the naso-pharyngeal cavity in the early part of the secondary stage. They are usually quite shallow, and are nearly always the result of the breaking down of mucous patches. Usually the ulceration begins in the middle of the mucous patch and gradually spreads to its periphery.

Excrescences resembling pointed condylomata have been observed on the pharyngeal mucous membrane in two cases by Schwartze. In connection with the morbid states above briefly described, we very often find redness and more or less [illegible] swelling and thickening of mucous membrane of the greater part of the cartilaginous portion of the Eustachian tube. Frequently there is also a great increase in the secretion from the mucous membrane, so that then on inspection the upper portion of the pharynx is found covered by or filled with it.

The subjective symptoms are those of ordinary catarrhal inflammation of the Eustachian tube, e.g., slight pain in the throat extending to the ear, especially on swallowing; pressure and a sense of fulness in the ear; more or less impairment of hearing, and subjective noises. Vertigo and headache are rarely complained of. Auscultation during inflation of the Eustachian tube through the catheter commonly reveals distant moist râles, which cease after the secretion has been forced into the pharynx. The drum-membrane shows changes here, as in simple catarrh of the tube, only after the ventilation of the tympanic cavity has been interfered with for some time, and these consist chiefly in a retraction and dulness of this structure.

The prognosis is always favorable under proper management of the case.

The treatment of the diseases of the Eustachian tube occurring in the secondary stage consists in the administration of mercury, the cleansing of the naso-pharyngeal space by means of the posterior nasal syringe or an atomizer; topical applications of weak solutions of corrosive sublimate or nitrate of silver to the mucous membrane of the naso-pharynx, and frequent inflation of the Eustachian tube through a catheter, or by Politzer's method.

In the tertiary stage, gummy tumors and deep ulcers, sometimes involving the cartilage of the tube, are occasionally met with at, or within, the faucial orifice. According to Zaufal,[52] the plica salpingo-pharyngia is most frequently the seat of gummata. They present themselves as round tumors of a yellowish-red or red color, smooth surface, and a broad base, varying in size from a pea to a hazel-nut. The deep ulcerations found in this stage of the disease are probably always the result of the breaking down of gummatous deposit. Such ulcers are, according to Schwartze, not infrequently found on the tubal prominence and at the entrance to the faucial orifice, together with similar ulcers on the septum narium, choanæ, fornix, posterior surface of the velum palati, etc., in cases in which the usual inspection without the rhinoscopic mirror fails to arouse a suspicion as to their presence. They have, however, been seldom found beyond the mouth of the tube. These ulcers frequently spread with great rapidity and cause extensive destruction. If seated on or near the mouth of the tube, a complete growing together of its walls may occur during cicatrization of the ulcer. The aural symptoms caused by an ulcer on or near the mouth of the tube, do not differ from those described under the head of diseases of the secondary stage. Pain referred to the ear is, however, more frequently complained of in connection with ulceration than with erythema and mucous patches on or near the mouth of the passage.

In the treatment of the tertiary symptoms our chief reliance must be placed on iodide of potassium alone or in combination with mercury. Locally, nitrate of silver, in substance or in solution, the acid nitrate of mercury, iodoform, or iodol, may be applied daily or less often. Thorough cleansing of the ulceration should precede the application of the remedies named.

Hyperostosis and exostosis of the osseous part of the Eustachian tube are, according to Gruber,[53] sometimes caused by syphilis. This is, however, denied by other writers.

MASTOID PROCESS.—*Osteo-sclerosis* and *hyperostosis* of the mastoid process are, according to Schwartze, sometimes caused by syphilis. We know of no signs by which a differential diagnosis can be made between the idiopathic and syphilitic forms of these diseases. A course of antisyphilitic treatment will, however, soon decide which form we have to deal with. Gummata of the mastoid cells are extremely rare. Superficial and extensive caries of the outer cortex of the mastoid process, without disease of the middle ear, occurs, according to Schwartze, only as the result of syphilitic or scrofulous periostitis. The syphiloma or gumma may develop under the picture of a periostitis of the mastoid process. It may break down in parts and simulate the feeling of fluctuation. Its development may be very rapid, and it may disappear as quickly under antisyphilitic treatment.[54]

THE INNER EAR.—Of the affections of the organ of hearing caused by syphilis, diseases of the inner ear are probably least frequently met with. These diseases usually make their appearance toward the latter part of the secondary stage, or at a still later period. According to Politzer, they are sometimes developed simultaneously with secondary skin or throat affections, and in one case observed by him, a disease of the inner ear appeared as early as the seventh day after the primary infection. The same author has also recorded a case in which labyrinthine disease was developed; simultaneously with a gumma of the skull, twenty-one years after infection; and the present writer has notes of a case in which sudden and absolute deafness of one ear, in connection with naso-cranial osteitis, occurred twenty-six years after the primary disease, and after an interval of more than twenty-five years of complete freedom from symptoms of constitutional syphilis. Hutchinson ("Syphilis," p. 32), on the other hand, has no knowledge of any form of deafness due to syphilis which occurs in the tertiary stage of the acquired form.

The diseases of the labyrinth may be developed alone or in association with tympanic diseases. Frequently they supervene on pre-existing catarrhal or purulent inflammation of the middle ear.

The *symptoms* of syphilitic disease of the labyrinth do not differ essentially from those of the affection of this part due to other causes. In this form, as in diseases of the labyrinth in general, a marked diminution or total loss of the hearing power in one or both ears occurs, usually more or less suddenly. Subjective noises, of a variable nature, often of great intensity, sometimes precede the onset of the deafness, but more commonly are developed at the same time. They are rarely entirely absent. Vertigo and unsteadiness of gait sometimes usher in the attack, but more frequently these symptoms follow the deafness. Nausea, vomiting, headache, and weakness in the limbs are also early symptoms in many cases. Pain in the ear very rarely accompanies the attack. Inspection of the drum-membrane will, in many cases, give a negative result, while in others it will reveal the changes usually found in connection with chronic catarrhal disease of the middle ear. Evidences of acute inflammation of the tympanic cavity are usually wanting. The air douche through the catheter commonly shows a pervious Eustachian tube, and the sounds heard on auscultation are generally broad and dry.

A closer examination of the hearing power in these cases shows that besides the impairment of hearing for the voice, the perception of sounds through the bones of the skull is either greatly diminished or entirely wanting. In cases in which both ears are deaf, vibrating tuning-forks placed on the vertex or between the teeth are usually not heard at all, and in cases in which only one ear is diseased, the tuning-forks are heard most distinctly in the healthy ear and never only in the affected ear. Placed on the mastoid process of the affected side, the tuning-fork (the writer usually employs for this purpose a small C^2 fork of 212 vibrations a second), if heard at all, is heard from this part less long than normally in persons of the same age. In cases of great impairment of hearing for the voice the employment of Rinne's test nearly always shows the predominance of aërial over bone conduction; while in total deafness for the voice small tuning-forks are not perceived at all, but very large ones, when struck with much force, are heard when placed on the mastoid process. The examination with the piano or tuning-forks of different pitch, not infrequently shows that the perception of certain tones of the scale, usually the highest, is diminished or destroyed, or that whole groups of tones are not perceived. In a case observed by Knapp,[55] tuning-forks of high and low pitch were not heard, while those of medium pitch were perceived; neither the highest four (e'''' – a) nor the lowest four tones (A^2 — D^1) were heard; the octave next to the highest was heard, and that above the lowest tones only feebly. The power of appreciating low tones is the last to suffer and the first to recover in most cases, so that these will be heard when the high ones are not heard at all, or false, or doubled.[49] In a case reported by Blake and Walton,[56] a tuning-fork (562 v. s.) was heard in the left ear one-fifth higher than in the right, and sixteen days later, tuning-forks (560 v. s. and 1,200 v. s.) which were heard through the air, and the tone reproduced by the patient's singing, normally in the right ear, were heard and reproduced below their pitch in the left ear; otherwise the hearing was equally good in both ears.

The course of this disease is not always the same in all cases. While the clinical picture usually presented is that of a very rapid decline of the hearing power, till complete deafness is reached, the progress in the impairment is in some cases comparatively slow. In cases observed by Politzer, nearly total deafness was present three days after the onset of the disease. Concussion of the head, sometimes of slight degree, will occasionally cause a rapid increase in the deafness in these cases (Politzer, Troeltsch, Urbantschitsch, Gruber). Fluctuation as the deafness so less often observed in the disease than in affections of the middle ears. The vertigo, unsteadiness of gait, and tendency to [illegible] generally continue for a few weeks or months and then gradually disappear. The hardness of hearing unfortunately very frequently remains, and in the few cases which recover the improvement takes place very slowly.

Syphilitic disease of the labyrinth cannot be distinguished from disease of this part due to other causes, by the special symptoms or the hearing tests employed. The sudden onset of the disease and the rapid progress of the deafness for the most part, together with the absence of bone-conduction, are regarded by many authors as peculiar to the syphilitic form of this disease. The present writer has, however, seen quite a number of cases presenting such a history in which syphilis was entirely out of the question, and therefore cannot regard the above-mentioned symptoms as characteristic of syphilis of the inner ear. If, however, the train of symptoms described occurs in connection with unmistakable evidences—in the skin, throat, or other parts of the body—of constitutional syphilis, or in an individual with a clear history of syphilis, we may assume with much confidence that the labyrinth disease is due to the invasion of syphilis. In the absence of a history or of other symptoms of syphilis, our suspicion as to its presence should be aroused, nevertheless, and we should make a searching examination for its presence in all cases of sudden loss of hearing, unaccompanied by pain, occurring in vigorous young or middle-aged persons whose nervous system was in a healthy condition previous to the attack, and in whom traumatism or other plausible causes of the deafness can be excluded (Schwartze). In several of such cases in which syphilis was absolutely denied, Politzer was enabled by a rigorous search to prove conclusively that constitutional syphilis was the basis of the ear disease. In this connection it should also not be forgotten that an outbreak of tertiary symptoms may occur after a long period of apparently good health.

The differential diagnosis between this disease and affections of the middle ear involves no great difficulty in recent cases. The absence of objective symptoms of middle-ear disease and the results of tests with tuning-forks and the piano will decide the diagnosis. The case is, however, entirely different if well-marked signs of middle-ear disease are present, and more particularly if both ears are diseased and the loss of hearing has developed gradually. Under these circumstances the results of even the most patient examination with tuning-forks and the piano will often leave it undecided whether one or the other or both parts are diseased. The supervention of syphilitic disease of the labyrinth upon middle-ear disease may be inferred from the history of the case, the suddenness of the increase in the hardness of hearing, and the result of the hearing tests previously mentioned.

So far as is known to the present writer, Roosa (op. cit., p. 613) is the only author who thinks that we are justified in going a little farther in our classification than merely to state this is a disease of the labyrinth. We may perhaps, he says, diagnosticate disease of the cochlea, or at least say that the affection of the cochlea is predominant in certain cases (great impairment of hearing, inability to hear certain tones, and the production of false tones), just as we may speak of disease of the semicircular canals, when vertigo and staggering gait are the predominant symptoms. To such cases he applies the name of syphilitic cochleitis.

With regard to the pathological anatomy of syphilitic disease of the labyrinth, it must be admitted that our knowledge is still in a very unsatisfactory state. Indeed Schwartze, than whom no one is better qualified to express an opinion on this subject, does not hesitate to say that we have no anatomical knowledge whatever of this disease, and that the pathological changes in the labyrinth found by Toynbee, Gruber, Moos, Politzer, and others, of which a brief account will be given farther on, cannot be regarded as specific, since the same alterations occur in non-syphilitic cases. The condition of the organ of hearing found post mortem in individuals in whom syphilis and ear disease were known to have existed, was as follows. In a case of secondary syphilis with catarrh of the middle ear, described by Voltolini, there was found hyperaemia of the vestibule, of the commencement of the cochlea, and of the horizontal semicircular canal, and hyperostosis confined to the parts surrounding the fenestra ovalis. Gruber found in a syphilitic subject who had become suddenly totally deaf, and who died from typhus fever, considerable hyperaemia of the mucous membrane of the tympanic cavity and of the membranous labyrinth, which appeared much thickened. The fluid in the labyrinth was abundant in quantity and bloody in color. It is not stated that a microscopic examination was made. Whether the changes found in this case were the result of syphilis or of the typhus must remain undecided.

Moos made an examination of the right petrous bone of a woman, forty-nine years of age, who had been very deaf on this side and blind in her right eye since her seventeenth year. The deafness and blindness were attributed by her to washing her head while in a state of perspiration. In the history of the case it is said that she had been treated for syphilis, but whether the infection occurred before or after the development of the deafness is not stated. She died from intracranial disease. At the autopsy, made by Professor Arnold, parts of the right parietal bone were found to be atrophied in consequence of gummy tumors. There were gelatinous oedema of the pia mater and hydrocephalus internus. In the right corpus striatum was found a fresh, diffuse haemorrhage. Old syphilitic scars were seen in the liver. The examination of the petrous bone, made by Moos, showed, besides alterations in the drum membrane and in the tympanic cavity, productive ostitis in the posterior semicircular canal. The stapes was firmly united with the oval window. The membranous structures of the vestibule and the membranous semicircular canals were in part intimately attached to the periosteum by connective-tissue bands, with the exception of the posterior membranous semicircular canal, which was much thickened but not adherent to the periosteum. In those parts of the semicircular canals which could still be isolated, the epithelium and the connective-tissue membrane were no longer distinguishable. They were covered partly by innumerable large and small cells lying close together. The bands of newly formed connective tissue between the periosteum and the connective-tissue membrane were also infiltrated with cells. The form and structure of the membranous portion of the vestibule were obliterated by a thick layer of hyperplastic connective tissue which covered the membrane almost everywhere. In some central places of the membrane, where the tissue was less opaque and more reticulate, the described infiltration of cells could, however, be observed. Where the newly formed connective tissue was most abundant there were seen numerous isolated, and in some places aggregated, globular concretions of phosphate of lime. The lamina spiralis was of a brown color; it was much thickened and appeared under the microscope very opaque, very vascular, and infiltrated with numerous cells; of its several zones only the denticulate region could be made out.

Commenting on the above Moos says: "The above described anatomical lesions of the organ of hearing furnish a sufficient explanation of the total deafness during life. Leaving out of account the myringitis which supervened toward the end of life, the deafness was due to the anchylosis of the stapes and the chronic inflammation of the labyrinth. Very probably this condition resulted from secondary syphilis, although the microscopic data would not of themselves point to it as a specific cause. As far as I know, we have not as yet reliable anatomical signs of syphilitic inflammation of the labyrinth. We know too little of the pathological anatomy of the labyrinth to be able to decide this question."

In another case of constitutional syphilis examined by Moos, in which violent subjective noises, vertigo, and pain in the bones of the skull were followed later by a remarkably rapid destruction of the hearing power, he found the following condition: The osseous substance of the petrous bone was destroyed wherever it was examined. The middle ear was entirely normal in every part. The labyrinth alone showed pathological alterations. The periosteum of the vestibule was slightly thickened; the foot-plate of the stapes was also thickened and immovable. The connective-tissue supports between the bony walls of the vestibule and the vestibular membranous structure were hyperplastic and infiltrated with small cells. The connective-tissue membrane itself of the membranous vestibular structures was likewise hyperplastic and infiltrated with small cells. The periosteum of the lamina spiralis ossea, as well as all the zones of the lamina spiralis membranacea, exhibited the same small-cell infiltration. The exudation consisted of small round cells, with a few oval ones containing a single nucleus, which were placed with regularity very close to each other. With regard to the degree of dissemination of the infiltration, it remains to be mentioned that the periosteum of the lamina spiralis ossea and of the zona pectinata was much less infiltrated than the zona pectinata and Corti's arches; the two last-named regions were so densely infiltrated that but few of the teeth and of Corti's arches could be seen distinctly; on the other hand, the infiltration was more copious in the ampullæ and sacculi, and in the connective-tissue supports between them and the bony walls, than in the membranous circular canals. The trunk of the auditory nerve was intact.

According to Politzer,[80] recent investigations leave no doubt that in cases of long duration, a chronic inflammation of the lining membrane of the labyrinth may result in a periosteal bone proliferation in the cavity of the labyrinth. The following case occurred in his own practice: The patient was a man, fifty years of age, who had been totally deaf for ten years in consequence of syphilis. In the right drum-membrane two broad, ribbon-shaped stripes extended downward at an acute angle from the end of the handle of the hammer. Bone-conduction was destroyed. Death was caused by phthisis pulmonalis. Autopsy: The ribbon-shaped stripes on the drum-membrane proved to be ridges of horny, thickened epidermis. The lining membrane of the tympanic cavity and the ossicles were normal on both sides. In decalcified sections of the cochlea, pathological alterations were mainly found in the ganglion-cells in Rosenthal's canal. Within these cells were seen small, round, granular cells without a distinct nucleus, and also oval and angular bodies, in only a few of which a nucleus could be recognized. (Atrophy and degeneration of the ganglionic cells in the ganglion spirale.) The modiolus showed in spots a reticular structure. In the spiral membrane, in the vestibule, and in the semicircular canals no changes were visible which could be interpreted as pathological.

Pathological alterations in the blood-vessels of the inner ear, similar to those described by Heubner as occurring in syphilis of the brain, have thus far been observed only in a case examined by Baratoux.

The *prognosis* must be guarded as regards the recovery of hearing. In acute cases of recent date recovery has occasionally followed the energetic employment of mercury and iodide of potassium; but in cases of gradual loss of hearing or in those of long standing, the prognosis is decidedly unfavorable. Politzer is of the opinion that the degree of deafness is not always decisive for the recovery of normal hearing, since recovery from total deafness has been observed; while, on the other hand, in milder cases, active antisyphilitic treatment not only fails to produce an improvement, but is, moreover, sometimes followed by an increase in the deafness. This author has also seen patients in whom the deafness came on while they were under the influence of mercury.

Treatment.—If the ear disease occurs during the earlier stages of constitutional syphilis, mercury should be be used freely, preferably by inunctions, till the system is brought under its influence; after that the remedy must be continued in smaller doses for a long period. Mercurial baths, subcutaneous injections of corrosive sublimate, and the internal administration of calomel, blue pill, and other preparations of mercury, may be substituted for the inunctions when they are objected to. The iodide of potassium, alone or in combination with mercury, is especially useful in cases occurring during the intermediate or tertiary stage. Roosa has obtained very encouraging results from this remedy in very large doses (120 to 369 grains daily), in cases where smaller doses failed to produce any effect. He used, however, inunctions of the oleate of mercury at the same time. To avoid disturbance of digestion it will be found best to dilute the iodide largely with water, and to administer it in divided portions during meals. Tonics and a generous diet should be given with both the mercury and the iodide to patients in feeble health. Subcutaneous injections of the muriate of pilocarpine, in gradually increasing doses (4 to 12 drops of a two per cent. solution), have also proved useful in this disease in Politzer's hands. He is of the opinion that it should be tried for from eight to fourteen days in all recent cases, and that mercury and iodide of potassium should be given only if at the end of the above-stated period no improvement is manifest. Lucae, Moos, Barr, and others also speak highly of the effect of pilocarpine in these cases, and think it worthy of further trials. Lucae has also seen temporary improvement of hearing follow the application of the artificial leech.

In order to protect the diseased ears as much as possible against the injurious effect of noises, while undergoing treatment, the patient should be kept in a perfectly quiet room, away from the streets, and it may even be advisable to cover the ears and the side of the head with cotton batting. If disease of the middle ear is present, this must be treated in the manner already described. Care should, however, be exercised, that the force employed during inflation be not greater than is absolutely necessary.

AUDITORY NERVE.—Of the syphilitic diseases of the auditory nerve, beyond the labyrinth, little or nothing is known. An intracranial disease, involving some part of this nerve may be assumed, however, if in addition to the symptoms enumerated under the head of diseases of the labyrinth, positive symptoms of intracranial disease are present in a syphilitic individual. Foci of softening in the brain, gummata, circumscribed basilar meningitis or pachymeningitis, chronic periostitis ossificans of the petrous bone, with hyperostotic narrowing of the porus acusticus, and paralysis of the trunks of the nerves from compression, are mentioned by Schwartze as the morbid conditions probably present in such cases. Of the morbid changes in the trunk of the auditory nerve and in its nuclei, due to syphilis, we have no knowledge

B. INHERITED SYPHILIS.—Affections of the ear due to inherited syphilis are met with at two periods of life, during the first year and between the fifth and twenty-fifth year of age.

In Infants.—In infants suffering from syphilitic disease of the nose and pharynx, affections of the middle ear are of common occurrence. Both the catarrhal and the purulent inflammations of this part, occurring under these circumstances, present no features by which they can be distinguished from the non-syphilitic form of inflammation. Caries and necrosis of the ossicles and the walls of the tympanic cavity, may perhaps be developed more frequently, or more speedily, in the syphilitic than in the ordinary form, but no statistics are available by which this is proved. As in many of these cases the general health is seriously impaired by the constitutional disease, often but little attention is given to the ear affection by the parents or the medical attendant of the infant, and treatment is delayed until great destruction has already taken place. In a case of purulent inflammation of both middle ears, of two months' standing which was recently under the care of the writer, paralysis of the right facial nerve existed when the patient was first seen, and paralysis of the left facial, and exfoliation of the hammer and anvil of both ears occurred a few days later. The child was greatly emaciated, and although mercury was given at once and the usual local treatment pursued, the child died two weeks later, apparently from marasmus. The prognosis is probably less favorable in syphilitic cases than in otherwise healthy children, but under proper general and local treatment, begun shortly after the appearance of the disease, many cases make a good recovery. Concerning the pathological anatomy of the diseases of the ear in syphilitic infants, we know but little. Baratoux ("Transactions of International Medical Congress," held in Washington, D.C., September, 1887) who made autopsies of forty-three still-born or new-born infants with hereditary syphilis, found lesions of the middle ear twenty-three times, lesions of the labyrinth four times, and lesions of both parts twelve times. When the internal ear was affected simultaneously with the middle ear, without pus being formed in the labyrinth, the walls of the ampullæ and cochlea were reddened; the axis of the cochlea was injected and infiltrated with round cells, and the parts were bathed in a sero-sanguinolent fluid which had taken the place of the lymph. When the internal ear alone was affected, the blood-vessels were found dilated, the walls were thickened, and in some instances hæmorrhagic spots were found.

The local treatment of these diseases does not require any other measures than those usually employed in the non-syphilitic form. Local treatment will, however, accomplish but little so long as the constitutional disease is active. For this mercury must be given; ten grains of the mercurial ointment rubbed into the palms and soles twice daily, as recommended by Hutchinson, will usually make the symptoms disappear very rapidly. Iodide of potassium is rarely beneficial in these cases.

IN CHILDHOOD AND ADOLESCENCE.—*The Drum-membrane.*—Special affections of the external canal and drum-membrane are doubtless of very rare occurrence in connection with syphilis hereditaria tarda. The only case of such a disease on record, so far as the writer knows, has been described by Pomeroy ("The Diagnosis and Treatment of Diseases of the Ear," 2d ed., p. 350) under the heading Papillo-tubercular Affection of the Drum-membrane in a Subject of Hereditary Syphilis. In this case, a boy, eighteen years of age, with parenchymatous keratitis and considerable impairment of hearing, both drum-membranes, just behind and below the malleus handle, were the seat of a nodular, grayish mass of triangular form. Large blood-vessels traversed the region of the tumors. Efforts to remove the masses by wiping with cotton wool were unsuccessful. After a few days the color of the tumors changed from gray to a dark red, and after the tumors had disappeared vessels of large size remained. Under constitutional treatment and inflation of the tympanic cavity the drum-membrane regained its normal appearance in about six months. Pomeroy infers that the tumors were in the dermal layer of the drum-membrane, as the malleus handles and short processes were distinctly behind the tumor. The drum-membranes were not perforated. It is not denied that there was more extensive disease than this, there evidently being an inflammation of the drum cavity with exudation into the tympanal lining, including that covering the round and oval windows. The tuning-fork tests pointed to a suspicion of labyrinthine disease, but actual proof of that was not given.

Middle and Inner Ear.—In the offspring of syphilitic parents, and almost exclusively in those of the female sex, between five and twenty-five years of age, there occurs occasionally a disease of the ears producing in most cases great impairment of hearing or total deafness in a short space of time. The connection between the ear affection and inherited syphilis was first pointed out by Hutchinson, though Toynbee and others had previously mentioned the occurrence of hardness of hearing in the children of syphilitic parents. Wilde's (op. cit., 266) familiarity with the disease under consideration is shown by his remark: "It sometimes coexists with, sometimes alternating with, the ocular disease." "What is termed strumous ophthalmia and also corneitis are the forms which the eye affection assumes. Occasionally it is that of iridochoroiditis." Since the appearance of Hutchinson's paper numerous cases of this affection have been put on record by various authors, and the clinical history of the disease is now well known, but our knowledge of its pathology is still very meagre. This disease is by no means of as frequent occurrence as the eye affection of inherited syphilis, and is, as has already been observed, found chiefly in the female sex. The present writer has met with it (or rather has seen it associated with well-marked symptoms of inherited syphilis) but once in a male, while he has notes of over twenty cases occurring in females. Other physicians have had a similar experience. The disease seems to be, from all accounts, of less frequent occurrence in this country and in Germany than in England, where, according to Hinton, five per cent. of the aural patients treated at Guy's Hospital, London, suffered from it.

The subjects of this disease of the ears have, in many cases, manifested symptoms of hereditary syphilis during the first year of their lives, and usually have enjoyed good hearing during early childhood. The ear disease usually begins between the fifth and twenty-fifth years of age, and is commonly preceded by an attack of parenchymatous keratitis or of an inflammation of the uveal tract of one or both eyes. Not unfrequently the ear disease commences while the eyes are still inflamed, and occasionally it precedes the eye disease. Painless swellings of the larger joints, more particularly of the knees, which pass away without much treatment, are often present at the same time, or are developed later on. In most of the cases the patients or their guardians are unable to assign an immediate cause for the ear trouble, but occasionally, as in one of Gradenigo's cases, and in one of the writer's cases, both of which occurred in young women, the deafness was attributed by the patients to exposure, particularly of the head, to draughts of cold air while the hair was wet. The first symptom to attract the attention of the patient, or of those who are with her, to the ear affection, is a sudden and marked impairment of hearing. Pain in the ear is almost never complained of. Vertigo, unsteady and staggering gait, subjective noises, and headache accompany the hardness of hearing in most cases. In a number of cases seen by the writer, vertigo and headache preceded the impairment of hearing, while in others these symptoms developed afterward. Occasionally nausea, vomiting, and headache usher in the attack. The hardness of hearing, which at first perhaps may not be of the same degree in both ears, increases steadily, and often very rapidly, to total deafness. Sometimes total deafness is found to exist as early as the second or third day after the beginning of the attack, but more commonly from six to ten weeks elapse before this stage is reached. Occasionally the progress is still slower, and is then usually characterized by marked variations in the degree of deafness from day to day.

The vertigo and the staggering gait usually continue for months and then gradually pass away. The deafness, after it has once become total, nearly always remains so. In several of the cases seen by the writer a perforative purulent inflammation of the middle ear of one or both sides developed several years afterward.

In the beginning of the disease the patients can usually hear the tuning-fork (the writer uses tuning-forks which, when struck with moderate force, are heard for from thirty to forty seconds normally when vibrating in the air near the ears) longer and louder through the air than through the mastoid process. The tuning-fork C⁴ (2,048 vibrations a second) is often not heard at all. In some cases bone conduction for tuning-forks of small size, of high and low pitch, is entirely abolished, while massive forks (for instance Politzer's C fork, described and illustrated in his "Lehrbuch," 2d ed., p. 117) are still heard through the mastoid. In cases of complete deafness of both ears, seen by the writer, he found that the tuning-forks C (128 V. S.), C¹ (256 V. S.), C² (512 V. S.) were heard both through the air and through the mastoid only when they were struck with great force, and louder and longer through the mastoid than through the air. None of these forks was heard from the vertex or when placed between the teeth, but the large C fork of Politzer (which is two and three times larger than the others mentioned) was heard from vertex and teeth. The tuning-fork C^4 was not heard at all. The shrill whistle of a distant factory was heard. Their own voices the patients could scarcely hear. In other cases of total or nearly total deafness of both ears, in which also only the large tuning-fork C was heard, the writer found sometimes a preponderance of bone conduction over aërial in one ear, while the other ear gave an opposite result. Gradenigo (*op. cit.*), who used tuning-forks of the same size and make as the writer, obtained similar results from his experiments. The examination of children with tuning-forks is, however, in most cases, very unsatisfactory in its results, as many of them are apathetic and indifferent, and can rarely be induced to produce, by singing, the tone of the fork, and one is, therefore, never certain whether they hear the fork or simply feel its vibrations.

The objective examination of the ear may reveal a perfectly normal condition of the drum-membrane, the tympanic cavity, and the Eustachian tube, or evidence of present or past disease of these structures. Acute catarrh of the middle ear will be found present in an inconsiderable number of cases, and changes in the drum-membrane, evidently the remains of bygone disease, in many others. Symmetrically placed areas of redness (localized periosteitis) on the posterior and upper wall, in close proximity to the drum-membrane, in both external canals, were observed in a well-marked case of this disease by Buck ("Transactions of American Otological Society," 1889, p. 62). Disease of the naso-pharynx is as often present as it is not. Perforating ulcers of the hard and soft palate, caries and necrosis of the naso-cranial bones, and ulceration of the larynx will be found in a small percentage of the cases.

The diagnosis of the peculiar ear affection under notice presents no difficulty if, in addition to the aural symptoms previously described, other symptoms of syphilis hereditaria tarda are present or have preceded the ear trouble. In addition to the eye diseases already mentioned, these patients often suffer from chronic inflammation of the knees or other large joints. The knees are often very much enlarged and locomotion may be painful, but there is rarely spontaneous pain. The disease usually passes off in the course of a few weeks, leaving the joints apparently in as good a condition as they were before the attack. Nodes on the long bones are also not unfrequently present. With regard to the peculiarities of the teeth, Hutchinson says: "If the upper central incisors are dwarfed, too short and too narrow, and if they display a central cleft in their free edge, then the diagnosis of syphilis is almost certain. If the cleft is present and the dwarfing absent, or if the peculiar form of dwarfing is present without any conspicuous cleft, the diagnosis may still be made with much confidence." Perforating ulcers of the hard and soft palates, deep ulcers of the pharynx, caries and necrosis of the naso-cranial bones, and laryngitis are less often seen than the other affections above mentioned. The patients, moreover, often have withered and old man-like features, a peculiar square form of the forehead, prominent frontal eminences, a sunken nose, and scars about the angles of the mouth.

With regard to this disease Hinton [34] remarks that he knows of no other affection, except fever, which in a person under twenty years of age brings on a deafness so rapid and complete, and Hutchinson says that it may be broadly stated that if a child or young person, without either earache or otorrhœa, becomes quickly and completely deaf, the patient is almost certainly syphilitic. The writer has, however, recently met with two cases, both in vigorous boys, without the slightest sign of syphilis, in whom nearly total deafness was very rapidly developed while they were in excellent health. No disease of the middle ear could be discovered, and no febrile disturbance preceded or accompanied the onset of the deafness. Examination failed to reveal intracranial disease at the time, and none has developed since. The parents of these boys absolutely denied having had syphilis. Other otologists have doubtless met with similar cases, and have, like the writer, come to the conclusion that hereditary syphilis of the ear cannot be diagnosed from the symptoms presented by the ear affection alone.

From the ordinary catarrhal inflammation of the middle ear (from which syphilitic children are no more exempt than others) the disease here described can be readily distinguished by the clinical history and the results of the local treatment.

In the absence of post-mortem examinations of the organs of hearing of typical cases of this disease, the writers on this subject are divided in the opinion as to the seat of the lesion. Hutchinson thinks it tolerably certain that the internal ear or the nervous apparatus is the seat of the affection, but as to the exact site and the nature of the morbid process he is still in doubt, and most English writers are of the same opinion. Politzer and Schwartze do not hesitate to speak of the disease as inherited syphilis of the labyrinth, and Gradenigo calls it a syphilitic otitis interna. The view that both the conducting and nervous apparatus are liable to be involved in this disease is held by Hinton and others, and Roosa has come to the conclusion that the disease is one chiefly of the peripheric and not of the central part of the organ of hearing. The view expressed by the writer in another place,[64] that disease of the nuclei of the auditory nerves might be the cause of the deafness, he has now abandoned, and a larger experience and further study of the disease leaves but little doubt in his mind that the labyrinth is involved in all cases, and that in many, both it and the middle ear are the seat of the morbid process. The apparently normal state of the accessible parts of the middle ear found in acute cases, together with the total deafness for the voice with which the disease ends, must be regarded as strong evidence that the auditory nerve is the part affected, and the absence of other signs of cerebral disturbance makes it positively certain that its terminal apparatuses are chiefly affected. The results of tuning-fork tests cannot be utilized, as we have seen, in the settlement of the question as to the seat of the disease. That in many cases evidences of disease of the middle ear are not wanting is generally admitted, but they are rarely sufficiently marked to account for the profound deafness. The usual treatment for the middle-ear affection of children, moreover, is rarely followed by improvement in the hearing, even in the cases in which, under it, the objective signs of the disease disappear.

The purulent inflammation of the middle ear, with perforation of the drum-membrane, which was developed in several of the writer's cases years after the attack which destroyed the hearing, may have been due as well to a gradual increase in the inflammation of the lining membrane of the middle ear as to an extension of a purulent inflammation from the inner ear to the tympanic cavity.

Treatment is generally regarded as of no avail in any except very recent cases. Hutchinson thinks it more than justifiable, having regard to the terrible results in prospect, *in early* stages of ear disease of this type from inherited taint, to confine the child to bed and induce ptyalism quickly. Knapp has reported a case in which a cure occurred under the use of mercury; but the writer, who adopted Hutchinson's advice in a number of cases, has been unable to arrest the progress of the disease in a single one. The iodide of potassium has been given in such cases by the writer for many years, and sometimes with apparent benefit, which, however, was generally transient. Buck saw marked improvement follow the administration of this remedy in gradually increasing doses (5 to 38 grains three times a day). If middle-ear disease is present, it should be treated by inflation and other means, and even in cases presenting no marked evidence of a middle-ear affection it is best to give the patient the benefit of the doubt and treat him locally as well. Pritchard advises repeated blistering behind the ear for several months in all cases, and as it can do no harm it may be worth while to try it. Hinton has seen striking improvement follow in a severe case from scruple doses of hydrochlorate of ammonia, and has seen good effects produced by the injection of iodine vapor with the tympanum in less marked cases. Favorable hygienic surroundings and a sufficiency of good food are, of course, to be insisted on in the treatment of all cases of ear disease, but, if the writer may judge from his personal experience, they have little or no influence on the course of this disease.

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Charles J. Kipp.

ENDOCARDITIS. *Definition.*—Accepting the definition of inflammation to be "the complex of changes occurring in tissues as the result of irritation," endocarditis becomes simply inflammation of the endocardium, the accepted definition. Many of the pathological processes, however, which constitute one form of the disease are evidently so closely allied to simple hyperplastic and hypertrophic changes, and are apparently so conservative in their purpose and protective character, that we are compelled to include in the class of irritants some causes which were more exactly regarded as only normal stimulants to nutritive processes. We cannot regard the connective-tissue development that occurs in valves subject to the strain of excessive blood tension, in either the ventricles or arteries, as any more "pathological," or any less conservative and protective in its intention, than the muscular hypertrophy, which finds its origin in exactly the same cause. Irritants, then, must be held to include all causes inducing reactionary processes which are potentially pathological. Under this acceptation of the term, the definition of endocarditis becomes exact.

History.—Bouillaud was the first to employ the term endocarditis, although Kreisig had previously recognized the relations between inflammatory changes in the endocardium and valvular disease of the heart. Vieussens, Lancisi, and some others following Harvey, described a few of the valvular lesions, but without assigning a direct relation to inflammation of the endocardium. Their studies represent the earliest contributions to the pathology of cardiac disease.

Laennec's discovery of auscultation gave an impetus to the study of cardiac disease, quite as important in its results in many ways as Harvey's discovery of the circulation. It was the clinical aspects of the disease, however, which were more especially developed by Laennec, Morgagni, Sénac, and earlier investigators. Sir Thomas Watson was among the first to describe the peculiar anatomical structure of the valvular tissues and point out its bearing upon the development of new tissue and influence in determining its distribution. Although his statements have been somewhat modified by later researches, the anatomical structure of the valves and their non-vascular character are still regarded as important elements in determining the nature of the inflammatory processes.

In the history of the pathology of endocarditis the investigations of Virchow, Luschka, Turner, Moxon, Wilkes, and, later, Cohnheim, upon the general subject of inflammation, found a direct application when the nature of the endocardial changes was considered, and tended to confirm the statement of Goodsir[1] that "an explanation of its phenomena is not to be looked for by referring them to actions of the extreme vessels, but to a disturbance of the forces which naturally exist in the extra-vascular portions of the inflamed part," a statement which finds special illustration in inflammations of non-vascular parts. In the more direct study of endocarditis Luschka developed more particularly the histological changes, and Virchow the sequelæ and complications. The history of infectious endocarditis does not cover a period of over twenty-five years, while researches within the past decade have made such radical changes in our ideas of its etiology as almost to render valueless all previous ideas.

Virchow, Kirk, Eberth, Lancereaux, and Moxon may be mentioned among the earlier investigators whose work was connected more especially with the pathological changes and etiology of the disease. The intimate clinical relations which ulcerative processes in the endocardium sustain to septic conditions had been clearly pointed out, but under the stimulus of Koch's discoveries pathologists sought to make clear the etiological relations, and to establish an unbroken chain of pathological elements starting in some specific cause.

Wyssokowitsch, Weichselbaum, Stern, Hirschler, Ribbert, and Prudden are among the more prominent of those to whom we are indebted for our knowledge of the relation of bacterial elements to the etiology of ulcerative endocarditis.

Much has been accomplished in this direction within a very recent period. Valuable contributions to the clinical history of the disease have been received from so many sources that an enumeration of authorities would include all the prominent clinicians of the past twenty years.

Classification.—From a pathological stand-point we recognize an entity of character in the various manifestations of this disease, with such variations only as may attend any inflammation. *Cellular infiltration*, the development of granulation or neoplastic tissue—which is the characteristic element of the pathological changes,—when rapid produces what is known as "simple or exudative endocarditis;" when associated with necrosis of the endocardial tissue it becomes "ulcerative;" while development of the cellular elements into fibrous tissue constitutes "interstitial" endocarditis.

It is evident that exudative must often develop into interstitial endocarditis, without any line of demarcation.

Upon an etiological basis we are compelled, by recent pathological studies, to recognize simple, or non-infectious, and infectious endocarditis; the former including, as a rule, the exudative and interstitial forms, and the latter corresponding to ulcerative endocarditis, although the non-infectious disease may possibly cause necrotic changes in the endocardium.

For descriptive purposes, a combined classification is not only more convenient, but also corresponds with three forms of the disease which can usually be recognized clinically, even when the transitional stages present no marked variations in the symptoms.

I shall therefore describe endocarditis under three heads:

1. Acute Non-Infectious Endocarditis.
2. Interstitial Endocarditis.
3. Infectious (or Ulcerative) Endocarditis.

Anatomy.—The endocardium is a non-vascular tissue composed of a connective-tissue layer with abundant elastic fibres. Its inner surface is made up of a single layer of flat endothelial cells. The membrane is connected to the muscular tissue of the heart by common fibrillated connective tissue which contains the nutrient vessels and a few muscular fibres. The valves are composed of prolongations of fibrous tissue from the fibrous rings surrounding the valvular openings. The endocardium passes over both surfaces of the auriculo-ventricular valves, and over the ventricular surfaces of the sigmoid valves, to their edges, where it joins the tunica intima of the arteries, of which it may practically be considered a continuation. The fibro-elastic body of the endocardium is thicker over the valves, and more abundant near their bases than at their apices. The auriculo-ventricular valves alone contain a few blood-vessels near their attached borders. Since the endocardial tissue is devoid of blood-vessels, it is evident that inflammatory processes must be attended by more or less extensive vascular changes in the subjacent connective and muscular tissue, and are thus prone to extend to these tissues.

NON-INFECTIOUS ENDOCARDITIS. — *Pathology.* — The vascular changes which form so prominent a part of many inflammatory processes are not marked in endocarditis, and are known to be present early in the connective-tissue vascular layer rather theoretically than from direct observation. As the exudative and hyperplastic changes progress, not only do the vessels become hyperæmic, but new capillaries are formed in the midst of the embryonic tissue, and this vascularization may extend deeply into the substance of the valves.

The essential and characteristic pathological process of acute endocarditis is found in a combination of exudative and parenchymatous changes. So far as we know, the exudation is composed almost entirely of white cells. If there is any free exudation upon the surface of the endocardium, it is washed away by the blood-current, leaving no anatomical indications of its occurrence. The cellular elements of the exudation, in connection with newly formed connective-tissue cells, become aggregated into nodular masses beneath the endocardium, causing irregular elevation and roughening of its surface.

These masses of granulation tissue, which are surrounded by a more or less diffuse infiltration of leucocytes, speedily become vascularized. The endothelium covering their apices disappears, leaving the new embryo-plastic cells exposed to the blood-current, and their roughened surface forms a favorable site for the deposition of thrombi. These thrombi are formed from the fibrin of the blood with entangled red and white blood corpuscles. When the granulation tissue develops about the bases of the valves and the outgrowths from adjacent valves come in contact, they become united and may form permanent adhesions between the valvular flaps or chordæ tendineæ.

Hyperplasia of the connective-tissue cells is an important element in the production of the new tissue. While the young connective-tissue cells are found most abundantly in the nodular masses, similar hyperplastic changes take place in the surrounding endocardium and in the areas where white-cell infiltration is most marked.

This cellular hyperplasia and infiltration is always attended by some softening of the intercellular tissue, with the development of a fluid within the endocardium which resembles mucin in some of its chemical properties. When the neoplastic tissue is developed with great rapidity or causes prolonged interference with endocardial nutrition, the softening may so weaken the endocardium as to allow of bulging and the formation of aneurisms, or even rupture of the membrane. The cellular masses, also, may either be torn from their bases, or undergo degenerative and necrotic changes which may extend to the surrounding infiltrated tissue.

In these degenerative changes pus is seldom formed, but granulo-fatty changes convert the entire vegetation into a débris of disintegrated cells, free fat globules, and blood pigment. A more rapid necrotic process may induce softening of the endocardial covering, with rupture and discharge of the contents into the blood-current.

Suppurative changes, when present, are most prominent in the masses of aggregated cells, and result in formation of minute abscesses, rupture of which leaves depressed ulcers. In connection with all grades of these inflammatory changes in the substance of the endocardium there occurs a more or less abundant deposition of fibrin from the blood upon the prominent, roughened, or ulcerated portions of the membrane and valves, forming thrombi. These deposits bear no special relation to the inflammation itself, but are such as occur on any roughened or inflamed endothelial vascular surface. They are formed more rapidly and abundantly in rheumatic and septic forms of endocarditis.

Morbid Anatomy.—In intra-uterine life endocarditis affects almost solely the right heart. After birth its seat is quite as invariably in the left heart.

Although any part of, or the entire endocardium may be involved, the inflammation most frequently begins in the valves, and seldom extends beyond the valvular orifices and the chordæ tendineæ. On the valvular surfaces the most abundant evidences of the inflammatory changes will be found at the bases of the valves and along the thickened line, a little distance from their edges, known as the line of closure. Upon the mitral valve, the points of insertion of the chordæ tendineæ will often be surrounded by the inflammatory processes, which also may have extended upon the chordæ. In the milder forms those areas near which the capillaries are abundant may present early a punctate or arborescent vascularity, only to become opaque as the exudation and hyperplastic changes occur. Generally there is little redness of the endocardium until the stage of vascularization of the new tissue. Before thrombi have formed on the endocardium, the affected surface presents a more or less granular appearance, being covered with small rounded or conical elevations corresponding to the points of cellular aggregation. When the exudative process is more extensive, these "granulations" become marked elevations, varying from the size of a hemp-seed to that of a pea, which either rest upon a broad firm base, or possibly have been drawn out until they are retained only by a mere pedicle. They are often so abundant as to form [illegible] masses along the base and edges of the valves, or fringed fringes about the attachments of the chordæ tendineæ. These vegetations are frequently seen projected along the thickened band which passes from the base of the valve to the Arantian body.

They become detached from the endocardium, and when forcibly removed, they bring away portions of the membrane, leaving a roughened line of attachment. It is seldom that the blood-current tears them away, but when this has occurred the remnants of the detached pedicle may be observed.

The thrombi which form upon the roughened vegetations vary greatly in thickness from a light film to a layer one or two, or even more, lines in thickness.

They are found on all the vegetations, but are most prominent upon those which are especially exposed to the blood-current, and are thickest on that part of the vegetation directly opposed to the impact of the blood. In appearance they are light in color, rather firm, and may be either conical caps, irregular raspberry-like masses, or attached bodies with filamentous prolongations. Detached portions of these thrombi, or crumbled bits of the vegetations, may form emboli that will pass into the general circulation, and initiate embolism and infarctions of the various organs. Pockets containing coagula or aneurisms of the endocardium will mark points of softening where aneurisms and valvular ruptures have been developed. Erosions and small irregular ulcers indicate detached vegetations or degenerative or necrotic processes. Such ulcers, however, are not frequent in simple endocarditis, and seldom present the dirty sloughing surfaces of ulcers found in the infectious form of the disease.

INTERSTITIAL ENDOCARDITIS.—*Pathology.*—The pathological changes of interstitial endocarditis not only may be, but often are, simply an advanced stage of acute endocarditis.

They consist essentially in the formation of new fibrous tissue, principally in the valves. As the intensity of the inflammation in the acute disease subsides the cellular elements of the vegetations become organized into a fibrillated connective tissue which passes on to the stages of maturation and contraction.

The vegetations shrink as contraction and obliteration of their capillaries take place, while the infiltration of the surrounding area assumes greater prominence, causing a more even thickening of the endocardium and less prominence of the vegetations. Adhesions between the edges of the valves, of the valves to the cardiac walls, or between the chordæ tendineæ, are even more frequent than in the acute disease. Acute necrotic changes are infrequent, but fatty degeneration of the neoplastic tissue and a subsequent calcareous deposit are of common occurrence. When the cellular infiltration and hyperplasia are not secondary to the acute process they are so gradual in their development as to escape notice, and the formation of the fully developed fibrous tissue goes on coincidently with cellular hyperplasia. In these cases the formation is in diffuse masses, more than in isolated nodules. Although the usual result is to strengthen the valves, points of softening may develop and be the cause of valvular aneurisms. This weakening of the endocardium and subsequent aneurismal formation is especially liable to occur when chronic endocarditis affects the wall of the ventricle.

When the inflammatory processes are an extension of an endarteritis of the aorta, the cellular exudation is at times more abundant, forming soft fleshy masses about the aortic orifice. This new tissue shows a marked tendency to become fibrillated, with a special liability to fatty and calcareous changes. As a rule it is confined largely to the aortic valves, although more typical interstitial processes may be going on in the endocardium. The development of new tissue is less closely confined to the endocardium in interstitial endocarditis, but extends to the adjacent tissue, and may involve the cardiac muscle quite extensively.

Deposits of fibrin from the blood are quite constant. They are most abundant and extensive on the auricular surface of the mitral and the ventricular surface of the aortic valves. When the free prolongations of these fibrinous masses reach from one valve to another they may cause adhesions, as between the mitral and aortic, which will produce most serious interference with the function of the valves.

Morbid Anatomy.—As in the acute disease, the marked changes are more commonly confined to the valves, or even to some portion of one valve; but any part of the endocardium may be affected, and that at the apex of the left ventricle is a frequent seat of chronic endocarditis. The endocardium will present all grades of change, from small opaque thickened spots scattered here and there over the walls of the heart and valvular surfaces, to the most extreme induration of the tissues.

The valves seldom present such prominent vegetations as in acute endocarditis, but are more uniformly thickened, in some cases to two or three times their normal thickness. This induration is generally most marked about their bases and edges, and gives the valves a firm, often almost cartilaginous and nodular consistency. They are inelastic, and often adherent for various distances from their bases toward the apices. Atheromatous and calcareous patches present yellowish chalky masses scattered throughout the valve substance, or appear as bead-like points strung along the free borders of the valves. Adhesions between the valvular leaves may result in the formation of a long funnel-shaped tube with a small opening at its apex, or a diaphragm with only a narrow slit through its centre. In many cases retraction is the most prominent change and the valves are curled up into rough, stiffened masses around the valvular opening, while less frequently extensive changes may have caused no disturbance of the valvular function. The chordæ tendineæ often share largely in the changes. They are found thickened, adherent, shortened, fused, or ruptured. When rupture occurs in those attached near the apex of the valve, the free end may be driven back through the valvular opening with each systole, causing sudden and extensive insufficiency. Aneurisms may rarely be found in the valves or interventricular septum, but are frequent when the endocarditis is of the ventricular wall or apex. The walls of such aneurisms are commonly smooth, and the cavity free from clots. When the wall is rough the cavity will be found with soft adherent clots.

INFECTIOUS ENDOCARDITIS.—*Pathology.*—Since the specific causes of infectious endocarditis induce their changes with far greater certainty in endocardial tissue which has undergone some form of injury, it often happens that the septic disease becomes engrafted upon either simple acute or chronic interstitial endocarditis.

In such cases the pathological changes and consequent morbid appearances of these conditions will be present.

Although pathological experiments upon the lower animals have seemed to show that some injury of the endocardium, however slight, is a necessary condition for the action of the specific cause of the disease, it certainly occurs in cases in which we are unable to state the nature of the injury causing that loss of endothelium which opens an avenue of entrance for the septic element. We are forced to the conclusion, which is not only rational but is supported by the facts in many analogous conditions, that defective vitality, incident to the constitutional poison of some precedent disease, has rendered the valvular endothelium unable to resist either the irritant action of the poisonous germs or the traumatism of the valvular action and the blood-current. Whether primary, or secondary to simple inflammation, the earliest changes of infectious endocarditis are probably associated with the entrance of bacteria within the substance of the endocardium. They enter from the free surface, where the endothelial covering has been removed, or rendered less resistant, and rapidly invade the connective-tissue layer, passing later to the deeper tissues and vessels.

Coincidently there is established an inflammation in which white-cell exudation is prominent. Necrotic changes develop rapidly in the affected areas, even before cellular infiltration is marked. The necrosed tissue is almost entirely devoid of nuclei, but the white-cell infiltration of the surrounding parts gradually extends to these necrotic foci.

The cellular exudation becomes purulent early, and both the ulcerated surfaces and the adjacent tissue are infiltrated with pus.

The affected tissue is more commonly thrown off by a process of disintegration, leaving ragged, irregular ulcers covered with shreds of sloughing tissue. Very rarely a granulation tissue may lift off the necrosed mass and form a healthy ulcer.

It is more than probable, however, that this occurs only when the ulceration is non-specific, since, as we shall have occasion to say later, specific ulceration of this tissue has resulted heretofore in death.

It is desirable to maintain a careful distinction between those ulcers in which necrosis is due to the specific action of bacteria, and those losses of tissue found in simple endocarditis which depend upon granular or fatty degeneration, consequent to a compression by rapid cellular exudation, causing defective nutrition.

When bacteria are found in such ulcers, or in the inflammatory products of an old endocarditis, they must be regarded as being accidental or consequent, and not an etiological relation, to the ulceration.

Softening of the endocardial and myocardial tissue, with the stretching and aneurismal developments already described, as well as rupture and perforation of valves, are more frequent than in the simple form of endocarditis. At times also the blood, entering on the floor of an ulcer, dissects a course between the valvular surfaces and underneath the endocardium in the heart muscle.

Thrombi, composed of fibrin, bacteria, red corpuscles, leucocytes, and blood-plates, form rapidly, both upon the ulcers and the necrosed areas, which, owing to their septic character, are specially liable to be torn off and form emboli.

Morbid Anatomy.—The areas of necrosis, which are most frequently found on the valves of the left heart, present an opaque, dirty-gray, or yellowish-white appearance of irregular outline. The surrounding endocardium is swollen, softened, lustreless, and opaque. After ulcers have been formed they appear as irregular but well-defined openings and depressions of the endocardial surface. Their edges are softened, thickened, and ragged, and their floor, which is formed of the muscular tissue of the heart, is covered with scraps of sloughing tissue and infiltrated with pus. Rarely it is covered with granulations. The thrombi which are adherent to the rough edges and necrosed tissue are of a reddish-gray color, soft, friable, and often strung out into long shreds. Within the endocardium may often be seen small abscesses, and lacerated valves and chordæ with aneurismal pouches give evidence of the extent and severity of the destructive changes. Under the microscope the edges and floors of the ulcers, with the adjacent endocardium and vessels, as well as the thrombi, are seen to be filled with bacteria, which are more frequently and constantly micrococci rather than bacilli. No single and constant bacterium has been observed. On the contrary, all observers agree that several different micrococci and bacilli have been found in the endocardial ulcers; although the staphylococcus pyogenes aureus and streptococcus pyogenes are the more constant and abundant.

Fränkel and Sänger found eight different micro-organisms in thirteen cases of endocarditis. Babes found (1) a coccus resembling that of erysipelas, (2) one similar to that known as Fränkel's pneumococcus, (3) tubercle bacilli, and (4) several spheroidal and oval micro-organisms, both single and in chains. Wyssokowitsch seems to have determined that the streptococus grows the faster, causing an anæmic necrosis, and the staphylococcus more slowly, with suppurative changes.

Prudden's investigations of ulcerative endocarditis, which seem to have been conducted with equal care and skill, give somewhat different results. In eight out of thirteen cases of ulcerative endocarditis he was unable to demonstrate the presence of bacteria, even by culture. Clinically, the bacterial and non-bacterial cases could not be distinguished. He also claims that only the streptococcus and staphylococcus have been found in man. These facts emphasize the point that septic and non-septic ulcerations cannot be differentiated by either the gross anatomy, the occurrence of emboli and infarctions, or by the clinical manifestations.

The infarctions in various organs and tissues, with their later developments into abscesses as well as petechiæ in the skin, all of which develop from occlusion of the arteries and capillaries by detached bits of cardiac thrombi and vegetations, may be considered part of the morbid anatomy. When a large vessel, as the popliteal or femoral, is obstructed, gangrenous processes may ensue. These all present the same pathological changes and morbid appearances as do septic infarctions in pyæmia, or from any other cause. Clinically, these manifestations become important parts of the symptomatology.

ETIOLOGY.—*Acute Non-Infectious Endocarditis.*—It is a well-established *belief* that the exciting cause of all forms of endocarditis is direct local irritation of the endocardium. It is an equally well-established fact that in non-infectious endocarditis we are unable to recognize any definite chemical element or physical body that is known to produce such irritation. The pathological characters of those diseases with which simple endocarditis is most frequently associated, render it extremely probable, nevertheless, that the chemical products of a perverted, retrograde metabolism are the offending elements and etiological factors in the disease.

It is not impossible, however, that a deficiency in some of the normal elements of nutrition, which have been consumed in excess by the unusual metabolic processes in the tissues, becomes an exciting cause of malnutrition, and secondarily of inflammation.

Certain cases of endocarditis suggest the possibility of central disease of the nervous system being the primary etiological factor in their development.

It has been proven that lesions of the nerve-centres may induce trophic disturbances in the endocardium as well as other tissues; but at present it seems probable that, in so far as nervous irritation is a cause of endocarditis, it acts secondarily through disturbances of systemic metabolism, rather than primarily upon the endocardium. We are, therefore, forced to confess ignorance of the ultimate or direct cause of the disease, and content ourselves with stating its clinical relations.

Acute non-infectious endocarditis is rarely a primary affection, but may be induced by traumatism. It is more frequently associated with acute articular rheumatism than with any other disease, and is not infrequently developed in connection with the subacute or even chronic rheumatic diathesis. Some statistics give the proportion of cases of acute rheumatism complicated by endocarditis, as from forty to fifty per cent. Others place it much lower. Previous attacks of acute, or the presence of chronic, inflammatory changes render the invasion of the acute process more probable in connection with rheumatism or any of the exciting diseases. Any one of the constitutional diseases in which the constituents of the blood are affected may be complicated by endocarditis. The exanthemata are especially liable to such complications. Scarlatina and measles head this class, and Wunderlich even places measles next to acute rheumatism as the most frequent cause. Bright's disease, gout, septicæmia, the essential fevers, and pneumonia are among the more common causes of simple endocarditis. Endocardial murmurs are frequently developed in cases of chorea, and it has been customary to regard this neurosis as a common cause of endocarditis. More careful observation seems to show that, while such a connection is both possible and not infrequent, many murmurs have been considered as due to inflammatory changes which were developed from other causes. It has also been supposed that a common cause was present in both rheumatism and chorea.

It is of the utmost importance to remember that endocarditis may develop, without the intervention of distinct rheumatic symptoms, after conditions favoring the perverted metabolism characteristic of rheumatism. That the irritant and [illegible] elements of exercise may induce endocardial sooner than arthritic inflammation, is entirely in accord with the clinical facts, viz., that we often find a fully developed endocarditis with the advent of articular symptoms, and that endocarditis rarely appears in connection with even the most severe cases of acute rheumatism after the ninth day.

The causes most constantly credited to produce the apparently idiopathic form of the disease may be classed generally as (1) an inherited rheumatic or gouty diathesis; (2) general malnutrition from improper or insufficient food; (3) exposure to changes of temperature, or prolonged and exhausting muscular strain; (4) exposure to septic influences.

Interstitial Endocarditis.—As already stated, interstitial endocarditis is frequently but the continuation of the acute process. But even when chronic from the outset, it depends in a very large proportion of cases upon the same causes. Next to chronic rheumatism, however, Bright's disease and gout assume the most prominent place in the etiology. In connection with these broad dyscrasiæ, we also remember a fibroid diathesis, which strongly predisposes, if nothing more, to the development of fibrous tissue in the cardiac valves as well as the arteries under trauma and other forms of irritation. It is in this form of the disease that we find that protective development of connective tissue, which has been referred to in our definition, under the persistent traumatism of the valves induced by high arterial tension and cardiac hypertrophy—a development which may eventually become distinctly inflammatory, and compel us to place high arterial tension and cardiac hypertrophy among the exciting causes of interstitial endocarditis.

Infectious Endocarditis.—It is a generally accepted fact that, under certain conditions, bacteria may be the exciting cause of necrotic and ulcerative processes in the endocardium, although cases having such an origin cannot always be differentiated either clinically or macroscopically. But we are inclined to doubt, while accepting the above as proven, that the presence of bacteria in endocardial ulcerations is indisputable proof of their having been the cause of such ulceration. Thus far, experimental proof goes to show that some lesion, either physical or nutritive, of the endocardial epithelium is a necessary precedent condition to entrance and pathological activity of the bacterial elements. Ribbert alone reports successful induction of ulcerative endocarditis by inoculation without previous injury of the valves, and that but infrequently. It is not difficult to believe, however, that many systemic conditions, or even the traumatism of the valves incident to high arterial tension and cardiac hypertrophy, aside from acute or chronic inflammation, may induce such depression of cellular vitality in the valvular endothelium as to deprive it of its natural protective power, and allow the invasion of bacteria found in the blood.

Clinically, infectious endocarditis occurs as a complication not only of the typically septic diseases, as pyæmia, diphtheria, scarlatina, puerperal fever, and osteomyelitis, but also with many of the specific forms of inflammation, as pneumonia and dysentery.

It does not seem necessary to suppose that the specific bacteria of these diseases become in turn the exciting cause of the endocarditis. On the contrary, it is more probable that they simply induce that degree of endocardial malnutrition which is necessary for the introduction of other forms of infective micro-organisms. Among the unique apparent sources of infection reported in infectious endocarditis, are osteomyelitis with suppuration, acute and chronic gonorrhœa, ulcer of the foot from an ill-fitting shoe, etc.

SYMPTOMS.—*Non-Infectious Endocarditis.*—Cases of simple endocarditis unattended by other disease, often present no symptoms of sufficient intensity to bring them to the notice of a physician. When developed in connection with some of the subacute manifestations of rheumatism, the cardiac symptoms may be less marked than is usually the case. Although often ill-defined and few in number, with no typical development either in order or intensity, they are characteristic and sufficient to call attention to more exact physical signs. Palpitation, which may be constant or induced by slight exertion, and which has occurred rather suddenly in patients before unconscious of their heart's action, is one of the most constant and important symptoms. It is often attended by a sense of constriction or discomfort in the cardiac area, which may become concentrated into a distinct localized pain, usually near the apex.

Dyspnœa usually accompanies the palpitation, or is developed upon slight exertion. The dyspnœa and palpitation may perhaps be recognized by the physician before the patient has become aware of their presence.

It is probable that an irritable action of the heart is all that can be ascribed to the endocarditis alone, and that severe palpitation with pain and dyspnœa indicate the presence of coincident myocarditis.

All other subjective, as well as many of the physical, symptoms depend upon the myocardial change. Of these, disturbances of the cerebral circulation are most common, as dizziness, vertigo, sleeplessness or delirium, syncope, and coma, with nausea and vomiting (see Myocarditis). The constitutional reaction is marked by a febrile condition in which the temperature seldom exceeds 102° F. Pain in the joints and organs, followed by nodular indurations which do not suppurate, are indicative of embolism and infarction. Embolisms of the cerebral or large vessels will be attended by characteristic symptoms.

Physical Signs.—Inspection.—In most cases the superficial evidences of endocarditis will be confined to the cardiac area. Early, the apex-beat is sharp and irregular but not displaced; later it becomes more diffuse and indistinct, but is seldom carried much to the left of its normal position. This change is never so marked or developed so suddenly as in pericarditis. When myocardial changes are extensive the heart's action is more tumultuous, and the patient's general appearance indicates deficient circulation.

The face is flushed at first, but soon becomes darker, or even livid; or it may become pale, gray, and cyanotic. These evidences of venous stasis develop earlier and more rapidly in children than in adults.

The surface becomes covered with a cold perspiration, and the dyspnœa, either constant or paroxysmal, causes most evident distress.

Palpation.—The sharp irritable action of the heart, as well as the increased force of the impulse in the earlier stages, is well appreciated by palpation. At this time the pulse is strong and forcible. Later, as the cardiac action becomes more irregular, the pulse decreases in force and volume, and may even become dicrotic, causing apparently a great disparity between the pulse and that tumultuous action of the heart, which is the excessive action of struggling weakness. As the disease progresses, the cardiac impulse is felt to be more irregular in rhythm and uneven in force. This unevenness varies from day to day, the heart at one time thumping heavily against the chest wall, and again giving hardly any perceptible impulse. When myocardial changes have taken place the weak impulse will be more constant, but it must be remembered that an intercurrent pericarditis is often the cause of sudden weakening of the apex-beat. The action is stronger when pain is present in the precordial area, and if this pain is due to pericarditis, it may be increased by pressure. An endocardial systolic thrill may be developed as the valves become roughened or thrombi form upon their surfaces.

Percussion.—The area of cardiac dulness is not usually increased. When incompetence or obstruction of the mitral valve induces pulmonary congestion and obstruction of the right heart circulation, there may be a slight increase in the area of dulness to the right. It is only when myocarditis leads to dilatation of the left ventricle that there is any marked increase in cardiac dulness. Sudden dilatation or distention of the cardiac cavities by blood, or coagula and fibrin, will produce such severe and characteristic symptoms as to render the percussion area of no importance.

Auscultation.—When the development of a case of acute endocarditis can be followed from its inception, the earliest auscultatory sign will often be the unusually clear, loud, ringing character of the cardiac sounds, most marked over the apex of the heart, and probably induced by the sharp, snapping cardiac contraction that is associated with the earliest irritation of the endocardium and intrinsic cardiac ganglia. Occasionally, in this early stage the heart-sounds are doubled by an irregular and inco-ordinate action of the ventricles. This doubling of the heart-sounds is more frequent, however, in the later stages, and is then often associated with a weak first sound and intensification of the second sound, most marked over the pulmonary valves. As vegetations and thrombi form upon the mitral valve, and before the characteristic murmur is audible, there is developed what many authors place as the earliest sign of endocarditis. It is prolongation of the first sound, so that it appears to run into the second sound. This is due to the loss of the valvular element of the sound. The swollen valves are not only softened but perhaps covered with thrombi, so that in this cushioned state they cannot close with the normal sharp impact. Loss of the valvular element alone, however, would not prolong the first sound, as stated by Sansom,[2] by leaving the muscular part to be heard alone. It occurs rather because there is already present a soft developing murmur so like, in its quality, the muscular part of the first sound, that when the valvular click is removed the ear is no longer able to distinguish the transition from the one into the other. When later this murmur has become louder and more characteristic in quality, the first sound is immediately shortened to its muscular part, and the ear readily separates the two without the aid of the valvular element. Endocarditis may develop one or several murmurs, and they may be located at the mitral or aortic openings. About half the cases of rheumatic endocarditis have a mitral murmur alone. Mitral and aortic murmurs are associated in about fifteen per cent. of cases. The characteristic murmur of endocarditis, as well as the most important and constant sign of the disease, is a systolic murmur which, beginning as a prolongation of the first sound, gradually develops a soft blowing quality of considerable intensity. It is heard most constantly at the apex, but does not of necessity indicate mitral incompetence, as it is often purely endocardial. This "bellows" murmur may change its point of maximum intensity with variations in roughening of the endocardium upon which it depends.

When cardiac hypertrophy and other evidences of pre-existing valvular disease are present, it is always difficult, and often impossible, to determine whether an existing murmur is recent or old. Some assistance may be found in the quality of the sound, but certainty depends upon watching the murmur as it increases. In such cases one may at times state definitely when a new endocarditis has become engrafted upon chronic interstitial processes. The mitral murmur of acute endocarditis is seldom conveyed to the back, as are the murmurs of chronic disease. Its point of maximum intensity is variable and its area of diffusion small.

The evidences of impeded pulmonary and right heart circulation are often prominent. Accentuation of the pulmonic second sound is quite constant, certainly when the heart begins to flag; and an increase of the normal leakage at the tricuspid develops into a distinct murmur in fully one-half the cases of mitral, and in over one-third the cases of acute aortic, endocarditis. These murmurs cease with the restoration of the circulation. The murmurs of aortic endocarditis are usually of the same soft blowing quality, but may be harsh or musical. The second sound is usually weak over the valves and entirely absent over the carotids in aortic endocarditis. The murmurs are always systolic, as incompetency of the valves does not occur unless they are lacerated or perforated by ulcerations.

In children the murmurs are generally confined to the mitral valve, and are often both obstructive and regurgitant.

Interstitial Endocarditis.—The symptoms and physical signs of interstitial endocarditis are all referable to lesions of the valves, and have been considered under Heart, Valvular Diseases of, to which the reader is referred.

Infectious Endocarditis.—Differences in the rational symptoms of infectious endocarditis from those already given for simple endocarditis, depend upon the greater severity of the endocardial changes, and the specific character of the constitutional infection.

All the symptoms given above may be found in the infectious form of the disease; a few additions only are necessary.

The subjective cardiac symptoms are, with perhaps greater frequency than in simple endocarditis, exceedingly obscure or entirely wanting; but the general systemic condition of the patient, even when the source of the infection is unrecognizable, or such as to forbid the suspicion of general primary pyæmic infection, presents such marked evidences of severe constitutional disturbance as to render it exceedingly improbable that the disease is ever entirely overlooked, as may happen in simple endocarditis.

The prominent symptoms are those of an acute infectious disease of an adynamic type. An initiatory chill, which may be repeated at irregular intervals, is followed by a febrile condition, whose chief peculiarity is its uncertainty and irregularity. Sometimes entirely absent or not exceeding 100° or 101° F., it is more commonly a sharp rise to 105°, 106°, or even 107° F. which continues, until the death of the patient, with irregular or distinctly periodic intermissions. Just before death supervenes, it may run very high or become subnormal. The patient, usually, passes very early into a typhoid condition with nausea and vomiting, and a rather persistent diarrhœa. A hæmatogenous jaundice is always slightly marked and may be extreme, or accompanied by a similar hepatogenous condition when infarctions in the liver obstruct the bile-ducts.

To these symptoms must be added all those dependent upon cardiac failure and embolic infarctions throughout the body.

Albuminuria and hæmaturia, however, may be present without renal infarctions.

Since myocarditis is quite invariably present, dyspnœa, palpitation, and cyanosis are usually prominent symptoms.

Of the cerebral, splenic, hepatic, arthritic, and pulmonary infarctions, it will suffice to say that some or all are almost always developed, and present the usual symptoms of such infarctions with a tendency to suppuration.

When infectious endocarditis complicates pyæmia or other severe infectious diseases, in which many of the foregoing symptoms have already appeared, the advent of the cardiac complication may be evidenced only by an intensification of the typhoid condition, and can be recognized with certainty only by the physical signs.

Physical Signs.—The physical evidences of an infectious endocarditis do not differ in kind from those given for the simple inflammation.

The evidences of cardiac failure are usually more prominent, and severe lesions of the valves, as rupture, and perforation, or rupture of the chordæ tendineæ, are not infrequent. These latter accidents are attended by rapid development of a typhoid condition which is speedily followed by the typhoid delirium and coma that always precede death in this disease. Finally, it must be admitted that cases of septic endocarditis complicating pyæmia, pneumonia, diphtheria, and similar diseases, may cause such slight change or increase in existing symptoms as to escape detection, although such a misfortune would hardly happen were the heart carefully examined from day to day in diseases liable to this complication.

DIFFERENTIAL DIAGNOSIS.—*Non-infectious Endocar-*

dium. Since the diagnosis rests mainly upon the physical signs, the differentiation is from other causes of cardiac murmurs, principally pericarditis, aortitis, functional and anæmic murmurs. Pericardial murmurs (friction sounds) are superficial in character, not necessarily synchronous with the heart-sounds, often double, with a to-and-fro sound and heard over only a limited area, which is usually at the base of the heart. They are often distinctly creaking, rubbing, or leathery in quality, are increased when the patient leans forward or takes a deep inspiration, and by pressure with the stethoscope over the præcordial area, and they disappear as the area of cardiac dulness is increased by fluid effusion. Pericardial sounds may obscure the cardiac sounds, but the murmur is there, and the valvular click can be distinguished so long as the cardiac sound is heard at all. On the contrary, the murmurs of acute endocarditis tend very early to obliterate this valvular element of the first sound, and cause an inseparable union of the cardiac sound and murmur. They are soft and blowing in quality, and when observed early are augmenting in intensity. They are more distant, are synchronous with the heart-sounds, and when double have the valvular sound between them.

Their point of maximum intensity is a predetermined point as a rule, and they are diffused beyond the præcordial area. Pressure does not increase their intensity, and they are often more distinct when the patient reclines upon the back. Endocarditis often gives a thrill, felt on palpation, which is not found in pericarditis.

Increased area of dulness is attended in pericarditis by cessation of pain, disappearance of the murmur and obscuration or loss of apex-beat; in endocarditis by increase of pain, often intensification of the murmur, and diffusion of the apex-beat.

Acute inflammation of the aorta is exceedingly rare—indeed some authorities doubt its existence. It is probably accompanied in most instances by similar changes in the aortic valve. Aside from the evidences of endocarditis there may be acute neuralgic pains which pierce the upper portions of the chest and shoot down the spine, or are reflected to other parts. The diagnosis is usually doubtful.

The diagnosis of functional and hæmic murmurs rests upon the recognition of a cause, their location at the base of the heart, the absence of evidences of change in the cardiac walls due to obstruction or regurgitation, their invariable systolic rhythm, and the absence of other signs of endocarditis.

It is often impossible to determine whether a cardiac murmur depends upon recent changes in the endocardium or chronic interstitial processes, and when a new murmur is added to one previously existing, it can be known only by repeated observations which display its development. Recent murmurs are usually soft and systolic, old ones harsh and often diastolic.

The myocardial changes of acute endocarditis tend to weakening and dilatation of the heart with weak sounds; those of interstitial change are hypertrophic, causing accentuation of not only the heart-sounds but their accompanying murmurs. (See Heart, Valvular Diseases of.)

Infectious Endocarditis.—The diverse manifestations of septic endocarditis have resulted in its being mistaken for several of the infectious diseases as well as some cerebral lesions. Hirschfeld recognizes two types of fever in this disease, corresponding to typhoid and the intermittent malarial fevers.

It has also been mistaken for acute phthisis. In many cases the diagnosis can be determined only by physical examination of the heart, and when a constant unchanging murmur is found at the first examination an immediate diagnosis may be impossible. The typical fever curve, abdominal pain and tenderness, and eruption of typhoid fever are wanting in endocarditis, while dyspnœa without physical signs of pulmonary disease, and embolic infarctions are not found in typhoid. In the acute severe forms of intermittent fever the liver as well as the spleen is enlarged and tender, which it is not in endocarditis unless infarctions have formed. In endocarditis the fever is remittent rather than fully intermitting, and quinine has little effect in controlling its exacerbations. During the intermissions of the malarial paroxysms the patient may be quite well, but in endocarditis the depressing effects of the disease do not abate.

A careful examination of heart and lungs can hardly fail to differentiate endocarditis from phthisis. When the endocarditis is of the right heart, pulmonary infarctions may produce all the physical signs of acute consolidation at the apex, with hæmoptysis. In such case an examination of the sputum for bacilli may be necessary for a diagnosis.

A meningitis of typhoid type following traumatism in a tuberculous subject may present all the symptoms of infectious endocarditis, except infarctions and the physical signs of valvular disease. Generally, however, the tension of the pulse is not lowered so quickly as in endocarditis, and dyspnœa without physical signs is absent.

It is evident that in all these conditions, as well as in some other general septic diseases, the diagnosis must rest mainly on the physical signs of endocarditis.

It is often a matter of importance to distinguish between ulceration in simple endocarditis and septic inflammation with ulceration. There are no physical signs of ulceration of the endocardium *per se*, and embolic infarctions do not of necessity imply ulceration.

Rupture or perforation of a valve will be attended by constant symptoms from whatever cause it may arise. The infectious or non-infectious character of endocarditis must be determined by the presence or absence of any suppurating source of infection or open wound, through which bacteria might gain access to the blood, by the number and course of infarctions, and by the general condition of the patient.

In simple endocarditis infarctions are rare, when developed are few in number, and produce simply mechanical effects without suppuration. In infectious endocarditis they are quite constant, affect numerous organs, and show suppurative inflammatory changes early. In the former the cardiac and constitutional symptoms are sthenic, and the signs of myocarditis are slight or develop late. In the latter all the symptoms become typhoid in character early; the mental depression and anxiety are out of proportion to the physical signs; the pulse becomes dicrotic or hyperdicrotic early, and a condition of mental torpor or typhoid delirium is rapidly developed. Cases of the infectious variety in which the symptoms are less severe, or in which remissions and intermissions are distinct and often prolonged, may remain uncertain until the end.

PROGNOSIS.—*Non-infectious Endocarditis.*—Death seldom results directly from simple acute endocarditis, although more or less extensive changes in the valves become permanent.

Nearly one-third of the cases of acute mitral endocarditis pass into the chronic interstitial form. When an acute inflammation attacks an already crippled heart, the sudden strain may cause a fatal myocarditis and acute dilatation, rupture or perforation of a valve, or rupture of one or more of the chordæ tendineæ.

The unfavorable symptoms indicating one of the above conditions are sharp pain over the region of the heart, sudden and intense dyspnœa, and cyanosis with rapid, fluttering, and dicrotic pulse.

When death does result from acute endocarditis, it is more commonly through a more slowly developed myocarditis with cardiac failure.

Infectious Endocarditis.—It is perhaps still true that recovery is not known ever to have followed infectious endocarditis. So true has this been that a favorable termination in any supposed case was regarded as proof of error in diagnosis.

Recently some cases have been reported which render it probable that recovery may occur in this disease. The percentage of recoveries, however, is still exceedingly small, although the diagnosis is never sufficiently exact to enable us to state this per cent. in figures. Unfavorable symptoms are those of myocarditis, valvular rupture, multiple infarctions, and the psychical indications of extreme systemic infection.

TREATMENT.—*Non-infectious Endocarditis.* Although perhaps not strictly included under the head of treatment, the question of prophylaxis, as applied to endocarditis, is of the utmost importance, and therefore strictly pertinent to our present discussion. Throwing out a small percentage of cases called idiopathic, which represent the extent of our complete ignorance as regards etiology, we find that all other cases of simple endocarditis are induced by diseases known to produce a perversion of the normal elements of the blood, or the development within the system of some new product which must pass off through the blood.

Of these diseases, one class, represented by rheumatism, is characterized by a simple perversion of metabolism; the other, of which measles is a type, possibly, if not probably, throws into the blood the products of bacterial growth. The fact that the endocardial changes induced by the poison of measles are often postponed for a long period, suggests at least that in this class, as in rheumatism, a weakened vitality has given way, and the etiological factor in the endocarditis is again the product of faulty metabolism, and not the direct result of bacterial action. In any event, however, we believe that the resistance which the endocardium, as well as the other tissues, offers to the irritant action of the *materies morbi* depends upon an inherent vitality, which in turn depends, not only upon present, but also upon previous and continuous conditions of healthy nutrition. Remembering, then, that the manifestations of the rheumatic diathesis are manifold, and that an acute endocarditis is often only the explosion following a prolonged stage of irritation, it becomes a matter of importance that children should be watched with care, more especially if descended from a stock with a rheumatic or gouty taint; and that the earliest evidences of malnutrition be met with prompt treatment by cod-liver oil and iron without waiting for "growing pains" and lame joints to confirm the diagnosis. The remarkable effects following the use of cod-liver oil and iron in these cases confirm the hypothesis upon which it is given. In cases of subacute endocarditis, or what often appears like a recurrent and intermittent acute inflammation in adults, characterized by increase of some cardiac symptoms that are only seldom entirely absent, the iron will often be found to give the most marked relief. In connection with these measures, the daily diet-list and clothing of children should be attended to with equal care, and always with the knowledge of any special inherited diathesis. It must suffice to say that the determination of an appropriate diet and clothing implies a consideration of all the conditions of gastric and intestinal digestion, hepatic activity, assimilation and excretion, either congenital or acquired. Upon the same basis we must urge a more careful and prolonged watchfulness of cases recovering from scarlatina, measles, and other specific diseases, or cases of chronic, suppurative, and ulcerative disease of the throat and tonsils, with a view to preventing possible endocardial complications.

No unquestionably effective measures have as yet been found for the arrest of an endocarditis once developed.

Absolute rest, so far as attainable, should be afforded the heart. The quieter action gained by the horizontal position is of the utmost value, and patients should be placed in bed and not allowed to indulge in even the most trifling exertion. Similarly, those remedies which tend to relieve arterial tension and quiet the heart's action, may assist in decreasing the inevitable irritation of valvular action. Very small doses of morphine, or preferably codeine, may be given, when the heart's action is very irritable, or when pain is prominent. Morphine cannot be given, however, with the same freedom as in pericarditis. In the earlier stages, when ventricular and arterial tension is high, $\frac{1}{100}$ ♏ doses of nitro-glycerine may be used tentatively. There are no other internal measures directed specifically to the inflammatory process. The use of mercury and potassium iodide, with a view to promoting absorption or lessening the deposit of inflammatory products and fibrinous thrombi, has been abandoned by the best authorities. The external application of ice-bags has been strongly recommended, and many German authorities uphold the practice. In this country the careful protection of the chest by cotton, or flannel, or the use of hot applications, either dry or moist, is the more common practice. The use of the cold coil, however, applied directly to the chest, or with an intervening layer of flannel, is gaining ground.

Stimulants are not desirable in the early stages of the disease. Their use is to be delayed until irregular heart action and the pulse tension indicate cardiac failure. Then they will be of decided value. The cardiac tonics, digitalis and strophanthus, may be indicated later, and when used should always be given in connection with alcoholic stimulants. Oxygen inhalations are occasionally of value when dyspnœa is excessive, but it must be remembered that defective circulation, rather than deficient oxygenation of blood already in the lung, is the cause of the distress.

Theoretically, every case of endocarditis presents a causal indication for treatment, but clinically, rheumatism, gout, and Bright's disease are about the only diseases in which we have any definite idea as to the nature of the etiological factor or the organ at fault in its production.

In gout and Bright's disease it is sufficient to say that we should use such remedies as stimulate the functions of the liver and kidney, especially mercury, colchicum, squill, or the milder diuretics. In that large class of cases, however, in which rheumatism is the cause of endocarditis, an accepted treatment is less definitely determined. Affirmatively, it may be stated as proven that the alkaline treatment pushed to the point of maintaining a complete and persistent alkaline reaction of the urine, is the most satisfactory as regards the endocardial inflammation. Negatively, it is equally well proven that salicylic acid and antipyrine do *not* decrease the danger of cardiac complications, while many, if not most, authorities hold that the prolonged use of the salicylates increases the frequency with which endocarditis develops.

As a result rheumatism is best treated, with a view to endocarditis, by the salicylates or antipyrine until the acute pain and the primary inflammation subside. Then the alkalies should be given throughout the course of the disease, and quite safely for some time after the subsidence of the acute manifestations. The salicylates should be withheld upon the slightest evidences of a developing myocarditis.

Infectious Endocarditis.—Flint's statement ("Practice of Med.," Ed. 1886), that "it is not known that recovery from acute ulcerative endocarditis ever takes place," has until quite recently been generally accepted. Within the past two years, however, several cases have been reported in which there was but little reason to doubt the diagnosis.

The most typical and valuable case, as offering hope of a more successful treatment, was reported by Sansom. This patient recovered from a condition that was typical of septic endocarditis. She left the hospital with a systolic apex murmur, but no hypertrophy, and otherwise apparently well. Some months later she returned with similar symptoms, and the post-mortem showed the lesions of infectious ulcerative endocarditis.

The treatment—under which this patient improved rapidly in the first attack, after having received no benefit from the usual treatment—consisted in the administration of thirty grains of the sulpho-carbolate of sodium three times a day, with free inunctions of carbolized oil (20 per cent.). With our present knowledge comment is valueless. We can simply hope that other cases may prove that the diagnosis was correct, and that the results were something more than coincident. The fact already alluded to under pathology, that the specific cause of the disease probably enters the valves from the surface and acts superficially rather than deeply, seems to offer some encouragement to the belief that the blood may be sufficiently loaded with an antiseptic to destroy the power of the infectious elements.

Beyond this the treatment is that of simple endocarditis. Since the septic condition is often present at the outset, antiphlogistic and sedative measures are seldom required, while the stimulant and tonic treatment must be employed from the first. Alcohol and the cardiac stimulants, with quinine and iron, will be tolerated in large quantities and very early. *Charles E. Quimby.*

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[1] [illegible], p. [illegible] 1885.

[2] [illegible] Lancet, [illegible] 1888.

HERNIA. It is not the object of this article to cover in its entirety the subject of Hernia. This has been done in a previous volume, and the work allotted to these pages is the much smaller one of giving a résumé of the latest and perhaps most generally accepted operations for attempting a radical cure of ruptures. At the same time, the writer has allowed himself the liberty of expressing his own personal views regarding strangulated hernia and its management.

Except otherwise specified, let it be understood that hernia of either the inguinal or the femoral type is under discussion. A strangulation here is but too common, and it behooves every practitioner to have, for his patient's sake as well as his own reputation, certain clear-cut ideas distinctly formulated as to these cases, so that an emergency shall not find him unprepared for the active treatment so often necessary in order to save life.

It is frequently impossible to say with certainty, whether in a given case simple incarceration exists—obstruction to the passage of fæces in an unreduced hernia; or actual strangulation—obstruction of fæces and also of intestinal circulation. I believe there is no positive guide in this matter. Pain and tenderness are no certain evidences for strangulation and against incarceration, though probable ones. Fæcal vomiting and hiccough may occur in both. Fortunately the treatment in either case is the same. A cathartic is best avoided. Give the patient morphine (gr. ¼) with a little atropine (gr. [illegible]) hypodermically. Atropine is a good preventive of shock in an operation that may be needed soon. The morphine enables taxis to be attempted without the local muscular contractions that might otherwise obstruct the endeavor to reduce parts that are in a state of considerable irritability, if nothing worse. It is a question, however, if we often have a tonic spasm here as a cause of the strangulation.

We should remember, in connection herewith, that morphine, by masking the symptoms and causing a lull, is apt to induce hopes from expectant treatment not justified by the event.

Should gentle taxis now fail, with the patient in the appropriate posture (flexion of the thigh, decided elevation of the foot of the bed), we may try for—say—one hour the application of either a hot poultice or ice, and then, gently, as before, repeat the attempt. Cold tends to contract the bulk of gas present in the gut, and may thus aid taxis. Just how poulticing (or the general hot bath) is of use, I cannot say—assuming that morphine has previously been employed to relieve any possible spasm. Very probably it is not of any use, although generally recommended, as poulticing often is elsewhere, when the attendant does not know what to do and feels the necessity of doing something.

The writer is decidedly of the opinion that an hour spent in this way is enough time to waste. If, after this period, another cautious attempt at reduction fail, then the attendant's duty is clear. It is to tell the patient that an operation is necessary in order to save life, and the sooner it is done the better the chances will be. Consent being obtained, and assistants procured, the surgeon should proceed to give relief.

This teaching may sound dogmatic, and the writer would not take such positive ground here as the result of a conviction that leaves no room for doubt. It is unquestionably true that many cases of strangulated hernia have been reduced and the patients have recovered, in consequence of prolonged and frequent taxis renewed at intervals during many hours, and at last successful. But many other cases are killed by just these means—the gut, either from the continued strangulation or from the taxis, rupturing or sloughing, with fatal consequences. On the other hand, herniotomy in careful and clean hands, performed with clean tools, is not an operation to be dreaded by either the surgeon or the patient. If done as it should be, and done early, and upon a patient not previously maltreated by taxis, there will be nearly one hundred per cent. of recoveries. To find dead gut in such early operations is a great rarity, and if found, the patient's general condition will be so much better and shock so much less that the prognosis from a kelotomy will not be a very bad one.

The writer was recently present at a meeting of the Surgical Section of the Academy of Medicine of New York, during which an eminent surgeon, greatly respected for his many successes, stated that in his judgment it would be a boon to the world if "taxis" and all attempts thereat were expunged from our text-books. This was, of course, putting the matter in a very vigorous way, for didactic purposes, and was not meant to be taken literally. But it shows clearly enough the drift of thought among surgeons at this day.

Yet it is seldom that the surgeon (as distinguished from the practitioner, who rarely sees the first phase) sees a case before twenty-four hours have elapsed since serious symptoms first made their appearance. During this time many attempts at reduction have been made—the more desperate ones none too gentle. Abrasion or actual rupture of the gut, with serious, perhaps fatal, peritonitis, is the frequent result. At last the surgeon is called in, operates, relieves the pressure upon the intestine, but the patient "dies cured," and the harmless operation, and not the previous malpractice, has to bear the odium in the minds of the family and their medical attendant.

The writer does not advocate any of the lame and halting measures so frequently suggested as an aid to taxis, neither Simon's method—the hand in the rectum to make use of traction upon the gut from within—for this is unsafe save with the smallest hand, and not entirely safe then; nor the passage of the finger (in the inguinal variety) up the scrotum or labium into the canal, trying with the finger-tip to stretch the constricting point, for this threatens rupture of the gut at the neck of the sac. The section of Poupart's ligament anywhere above the inguinal canal, recommended in order to relax the rings of the canal, to be followed after reduction by suturing of this ligament, seems to the writer also objectionable, because it is a blind method. All these, and the several other plans advocated by various authors in order to dodge a plain duty, have at least one fault in common. They do not open the sac and give the operator a view of the gut, which may be ruptured, ulcerated, dead, or dying.

It is not claimed that these and still other methods are never successful, but it is distinctly claimed that delay is very perilous; and the former teaching, that opening the sac increases the mortality, is not now, as it used to be, a statement of fact; not, at least, in the practice of men who know what the term *surgical cleanliness* means. The peritoneum is no longer the "sacred sac."

The advantages of opening the sac, on the other hand, are numerous. Reduction *en masse* is thereby avoided; a possible strangulation within the sac, or, more probably, such inflammatory adhesions of gut to gut as will prevent the passage of fæces, even though permitting circulation of blood, are relieved; dead or dying gut or omentum is seen and treated appropriately. In a word, it is daylight against darkness.

The question, how long can the gut live while strangulated, is one that never will be settled so that a limit of time can be formulated. The answer depends upon two factors, the tightness of constriction and the vitality of the patient. If constriction of circulation is absolute, probably an hour or two may suffice for death from [illegible] at the constriction, and passive congestion, with stagnation, beyond. If even a little blood can flow, the gut may retain vitality, as I have seen it do after forty-eight hours of strangulation, with apparently urgent local and constitutional symptoms. Vitality is a vague expression, but nevertheless stands for an entity that all must recognize, and which varies widely in degree among people apparently in equal physical vigor.

Not only should the sac invariably be opened, but it should be opened *before* relieving the constriction at its neck. This is because the gut is liable, if not adherent within the sac, and not prolapsed in large amount, to slip back into the peritoneal cavity as soon as the undue pressure upon the neck of the sac is removed. And then the operator, upon opening the sac and failing to find it, will be compelled to choose one of the horns of a dilemma—either to do nothing further and assume that the contents which slipped back were living, or else, if his conscience will not allow this, he must take the risk of a laparotomy and look up the missing bowel or omentum; which he can probably best do (if the hernia is inguinal) by an incision running up from the internal ring a sufficient distance.

The original incision in a herniotomy should be in length at least equal to that of the tumor, and in its direction the same as that of the long axis of the tumor. This I think to be the best rule, whether the hernia be of the femoral or the inguinal variety. Careful dissection with a light hand, and either the grooved director or two pairs of forceps for safety, will quickly expose the sac, which in recent cases will be smooth, tense, and shining, and apparently not fibrillated, but rather of homogeneous texture; in other words, presenting the usual peritoneal appearance. On opening this slightly, there will generally be an escape of colorless or dark fluid—not blood—and omental fat will probably force itself out at once from the great internal pressure, or else the more or less discolored gut will be seen, always darker in hue than the normal bright pink, and varying between a dark-red, in favorable cases, and absolute purple-black. Occasionally, however, especially in neglected cases, in which the sac is inflamed and adherent to surrounding structures, perhaps even gangrenous, there may be some little difficulty in distinguishing between this and the peritoneal coat of the gut. To differentiate, cut very lightly and superficially through the presenting membrane for half an inch or so. Then take a grooved director and gently introduce it. If the severed membrane be sac-wall, the director will easily pass within in various directions. If it be the peritoneal coating of the gut, the director will, of course, not pass with any degree of readiness between this and the muscular layer.

After ample incision, in order the more readily to examine the sac-contents, it is well to seize its cut edge at several points with artery forceps and draw it out into a funnel.

The sac being freely opened, the next step is to divide the constriction—first securing control of the gut by a loop of stout silk or catgut passed through the mesentery. The division should be free or not, depending upon the state of the gut. If this is in a condition allowing immediate return, then a few slight nicks in the classical directions may be all-sufficient, if they permit its return without much handling and friction. Before return, however, it should be sufficiently drawn out to make sure that there is no ulceration at the tightest point.

The treatment of the presenting omental masses, whether dead or not, is always the same. They are ligated at as high a point as possible, cut away, and the stumps, after irrigation, returned to the abdomen. If their bases are at all large it is well, for security against hæmorrhage, to transfix with a double ligature and tie off either side. They are more often adherent in the sac than is the intestine, probably on account of the constant vermicular movement of the latter.

All adhesions should be broken, save when a speedy end of the operation is a necessity, or when the gut must be left out for a time. Adhesions to the gut require careful dissecting away. For safety to the gut it is sometimes necessary to excise a little of the wall of the sac, leaving it adherent to the gut.

If the bowel be found in a doubtful state, or actually dead in any part, or if, though apparently sound, there be difficulty in returning it, then the division of the compressing tissues should be free indeed. And here I am inclined to advise an open dissection—not the usual nicking in the dark with a hernia knife, but daylight work—cutting not only Gimbernat's but Poupart's ligament, if necessary, in the femoral variety, and cutting upward from the deep ring freely, in the inguinal, the external oblique aponeurosis, forming the anterior wall of the inguinal canal, having, of course, first been slit its entire length—nearly two inches. By cutting down in this way cautiously, step by step, the deep epigastric artery will, if in danger, be seen and can be avoided; or, if very annoying, may be tied and cut. Provided the operator tie first, it is of little importance whether this rather small vessel is or is not cut, and it is not worth the worry devoted to it by the text-books; and if cut accidentally, it may be seized with a pair of artery forceps and tied with perfect ease, as it is in plain sight and in an open field; whereas if the surgeon follow the more usual plan of nicking in the dark, and happen to cut it while trying to make an opening of some size, there may be difficulty in controlling the spurting vessel which he cannot see.

In any case, it is rarely necessary to open the peritoneum farther than is done in opening the sac. We simply cut, down *to* the peritoneum, a sufficient distance to free absolutely the gut within the rupture from any pressure whatever.

Now comes the question, Is the doubtful gut dead or only threatened with death? If the former is the case, it will be very dark, probably lacking in lustre more or less, and when pinched will show no peristalsis. Neither will Nothnagel's test, with a piece of salt placed upon it, induce vermicular movement. If firmly pinched for a minute between the finger and thumb, the dark blood thus squeezed away from one spot will show no tendency whatever to return. In cases in which decomposition is beginning, it will be actually sticky, apparently shrunken somewhat, and thinner than normal to the feel. The offensive and peculiar odor of putrefaction can in these bad cases be detected; an odor differing from the merely fæcal smell.

If the bowel is wavering in the balance between life and death, it will be decidedly dark. But darkness alone does not necessarily mean death. I have seen a gut almost black resume its natural color within a few hours. Upon pinching such a gut there will probably be some slight peristalsis induced, and to the comparatively pale spot caused by prolonged firm pinching the blood will very gradually return, showing the existence of some little degree of circulation still.

Assuming, now, that the gut seems dying, but is not yet dead, or is at least doubtful, there is but one course open to the surgeon—he must await events; putting that gut meanwhile into a condition, as to its environment, as nearly normal regarding warmth, moisture, and asepsis, as possible. It would be entirely inexcusable to return a doubtful gut to the abdominal cavity and sew up the wound, trusting to luck that it may live. That course is sometimes pursued, but it is not good surgery; it is reckless surgery. Should it die, the first evidence thereof will be a septic peritonitis, in all probability fatal.

The surgeon can with propriety, after thorough irrigation with a warm, weak antiseptic solution (Thiersch's boro-salicylic, for instance), return the gut to the belly, controlling it, however, by means of an anchoring-thread of large-sized catgut through its mesentery; and can devote a quarter to half an hour in work, partly on the omentum, if present, ligating and cutting it away, and partly on the canal, dissecting up the sac, passing but not tying the stitches, and making all the preparations for the operation for radical cure. It is assumed, of course, that the general condition of the patient justifies such a prolonged operation. Finally the gut is drawn by the anchoring thread into view again. If it is distinctly better in color, the thread is removed and the radical operation completed. If the gut is still doubtful, the wound must be amply enlarged at its deepest part, the gut drawn forth so that the suspicious portion is, if possible, several inches from the peritoneal cavity, and moist iodoform gauze in several turns packed uniformly about the gut at its point of emergence so as to make sure of the prevention of any penetration to the peritoneal cavity in case of inter-partial rupture of more dead spot, with faecal escape. The retention thread is made fast to the skin, and finally, the bowel and hernial sac are wrapped in warm, soft aseptic cotton loosely laid on thin rubber tissue which is moistened with a very weak antiseptic solution. The steady temperature desired—100° to 105° F.—is best maintained by means of Leiter's coil—preferably of rubber tubing, as this is less heavy than the block tin. In default of a coil with running hot water the heat is maintained by siphonage from a bucket of very hot water placed on a shelf higher than the patient. The water trickles slowly, and the gut-temperature is regulated by the number and thickness of the cloths covering it. (See article Fomentations, Vol. III.)

The patient is, of course, now allowed to come out of anaesthesia. At intervals of an hour or two the gut is cautiously uncovered in a warm room as before, and examined. Whenever it seems safe to return it, the operation may be completed, and very probably without anaesthesia, especially if the stitches have been passed and are lying loosely, only awaiting tying. On the other hand, should the state of the bowel become worse and death overtake a small portion of it, or more, then the treatment to be adopted is the same as if this state of things were discovered when the sac was first opened.

Part of the gut being found unquestionably dead, there are three courses of action open to the surgeon:

(A) He can simply leave the gut and wound prepared as we have just described it and await events. These will be sloughing and the ultimate escape of faeces, contaminating the wound, but probably not its deeper parts, which have been protected by the thick layers of gauze. The gut, if not adherent to the sac at first, will become so within a few hours, and nature will make the artificial anus awaited further by the surgeon. Whenever the deeper dressing is changed—which must be very frequently—the new anus is carefully closed, the wound irrigated, dusted with iodoform, the iodoform gauze packing removed and replaced with fresh. Stitches may be taken to narrow, but not to close, the canal about the gut, which heals by granulation from the bottom. It would be unsafe to attempt an immediate closure by suture, as in method B, of a wound large, deep, and irregular in outline which has been poisoned with faeces.

While the method just detailed is allowable, it seems to the writer objectionable save in cases where sinking of the patient demands a hasty termination of the operation, or where the sac is putrid or septic to any extent. If a somewhat longer time can be permitted—say half an hour—then method B is preferable, and is the one actually employed in perhaps the greater number of cases.

(B.) Here the artificial anus is made by the surgeon, not by nature, and without waiting for spontaneous rupture of the dead gut. Under this head we have choice of three plans, and no fixed rule can be given as to which is always preferable.

I. Here the surgeon simply frees the constriction, draws the gut out and lifts it gently away from the wound, protects the wound by packing, excises the necrosed part, allows thorough fecal evacuation, cleanses the cut ends, and makes an immediate artificial anus. If an entire loop is dead, there will, of course, be two intestinal ends. It is commonly easy to recognize the proximal end as being that one which contained the most faeces and gas. But commonly both ends are kept open by sutures. The steps may now be as follows: The peritoneal coat of the gut is first stitched to the cut edges of the sac by one or two rows of sutures, and then the muscular-mucous coat to the skin. Finally, the rest of the cutaneous wound is closed, except for drainage; this may be provided for by a rubber drain, or better by some iodoform gauze packing, reaching to the bottom.

II. Here the constriction is freed as before. Then the peritoneal coat of the gut is sewn to the cut edges of the sac and tied, and may be to the skin. The remainder of the wound is sewn, loosely packed or dressed, as in I. Twenty-four hours are allowed to pass before the dead part is cut away (unless it ruptures spontaneously), when the faeces are allowed to escape. It is not necessary, but is sometimes done, to stitch the muscular-mucous coat to the skin after opening.

This mode of procedure (II.) allows time for firm adhesions to form, giving peritoneal protection from septic infection, and is identical with the technique used in the preliminary steps of gastrostomy, inguinal colostomy, cholecystostomy, etc.

III. Here the constricting point is not severed, but otherwise the steps are, as far as possible, as in I. It is a question of great interest whether this third mode is or is not justifiable. There are eminent authorities on both sides. Mitchell Banks has put his views very forcibly. He strongly disapproves of severing the constricting point, because emptying the prolapsed gut will relieve the constriction, and the more readily as the faeces in these cases are, he says, invariably quite liquid, and because "the only result of this [cutting the point of tension] is that the protecting barrier which isolates the still aseptic peritoneal cavity from the putrid sac is broken down, and putridity spreads upward into the abdomen and kills the patient by rapid septicaemic poisoning. Why break down this valuable wall?"

The writer must dissent from this view of the case, and prefers the first technique in method B for several reasons. First, it is entirely possible to prevent sepsis and peritoneal infection, if the wound is first carefully disinfected and then packed with iodoform gauze before the drawn-out gut is opened and allowed to empty itself. In fact, it seems to me more feasible by this means to escape infection than by leaving the constriction, which is not a perfect barrier at all points of its circumference, especially after the tension from retained faeces is removed. Second, if the constriction is not relieved, it is difficult, if not dangerous to the gut, to draw it out and away from the wound before emptying it; and if it is not so drawn out, the wound surely runs a greater risk of infection. Third, it is not a fair assumption that the constriction is always due to a "swelling of the loop of gut" (Banks); it is often caused by the straining of an *additional* and unusual hernial knuckle into the inner ring; therefore, simply to empty the prolapsed gut is not invariably to relieve tension at the neck of the sack; and a small, tightly nipped knuckle, deeply placed, could readily be overlooked and not relieved by the method advocated by Banks. Fourth, unless the gut could be easily drawn out, a serious ulceration caused by constriction, with threatened consequent perforation, would be likely to be overlooked.

By whatever method the surgeon makes an artificial anus, he should contemplate, in logical cases, a subsequent operation to close this opening and restore the continuity of the bowel; and this should be attempted just as soon as the patient's general condition will permit. Kocher has stated that every case under his care (seven in number) of artificial anus resulting from gangrene has come to an untimely end from some cause more or less directly due to its presence. Within a very few weeks the gut below the lesion shrinks and atrophies considerably. And if the small intestine be the part affected, this, reducing so closely the maintenance of the patient's nutrition, gives an additional reason for hastening the closure of the artificial anus, the technique of which operation does not come within the scope of this discussion; it is enough to say that the gradual methods, such as that of Dupuytren, are being less employed of late.

Although Kocher has had such unfortunate results with his patients, this has not always been the case. There might be allowed an exception to the rule of early obliteration of some artificial anus, in cases where only a small spot has sloughed, and where the large gut or the lower ileum is the part affected. Several cases have been reported in which a spontaneous cure has occurred, the gut being apparently drawn gradually back into the abdomen by continued vermicular motion, and the artificial anus becoming so gradually a mere fistula which has finally closed. Unless the patient's nutrition and strength seem satisfactory, however, it would be very unwise to wait for this rare occurrence.

We have considered two of the three methods whereby we may treat a case in which, on opening the sac, the gut is found dead ; or if doubtful, has subsequently died.

(C). There remains a third method which deserves attention, although rare of application and unsafe in the hands of those who have not had opportunity to practise it upon the cadaver, or upon the lower animals. This is the resection of the dead part, and the immediate restoration of the continuity of the gut by circular enterorrhaphy, or some plan similar in that it avoids an artificial anus.

The advantages of this mode of disposing of the case are great. At one stroke the patient is cured, and the annoyance and danger of an artificial anus, with the almost inevitable subsequent operation or operations for the abatement of this nuisance, are avoided. But, on the other hand, the operation is long and trying, and therefore one which extremely few cases of strangulated hernia can endure. They are generally relieved by surgery late in the case, unfortunately, and are more or less in shock at the time of operation, which must hence be as brief as possible. The actual treatment of the gut and mesentery alone, takes from one to two hours in accustomed hands. It requires more time to do properly, with not a stitch too tight or too loose, too deeply or too superficially placed, than anyone realizes who has not tried it. I have demonstrated this operation now about fifty times, upon as many subjects, in my operative surgery classes at the New York Polyclinic ; and it is always most tedious. Since speed is so tremendous a factor in the problem of success in bowel-work, we shall all heartily welcome any device which cuts short the duration of operation, and yet gives a perfect result. It may well be that in Dr. Robert Abbe's catgut rings (see Fig. 4892)—an improvement on Dr. N. Senn's decalcified bone plates, seeming at least as safe, and being always ready at hand—we have the means of saving many lives through point of time. I have not yet had an opportunity to invert the gut-ends, close each with Lembert stitches, point the overlapped ends in opposite directions (as Abbe has suggested, to get a continuous and not an opposing peristaltic wave in the two ends), and, opening the two sides, apply the rings. I should think that quite a little time might be saved by this method as compared with circular enterorrhaphy.

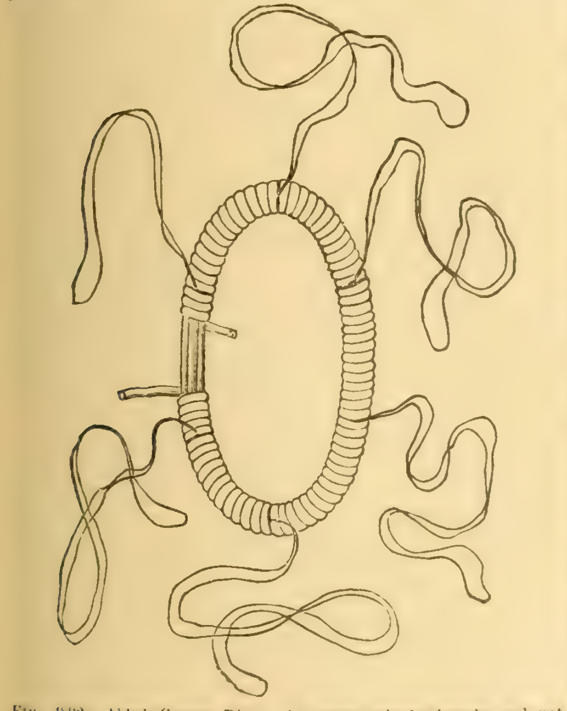

FIG. 4892.—Abbe's Catgut Ring. At present single threads, and not loops as in the cut, are used in uniting the two rings.

If the surgeon, however, deems it safer to suture the ends by the Czerny method, previous to inversion and the Lembert stitch, then nothing, it would seem, would be gained ; for twice the diameter is equal to two thirds of the circumference of the bowel ; and it would probably take no longer to put two tiers of sutures into the remaining third than to open the sides, insert the rings, fasten them by their threads, and then take the few Lembert stitches advised for security.

It might be a good plan—both with the idea of saving time and to avoid the formation of the cæcal pouches on either side of the new opening, caused by the occluded end of the intestine—to place the catgut rings within the ends of the gut, as an aid to ordinary circular enterorrhaphy. This I shall try at the first proper opportunity, provided the cadaveric test is satisfactory. (Dr. Abbe's article will be found in the *New York Medical Journal*, March 23, 1889.)

As has been stated, the treatment of dead gut by immediate resection and enterorrhaphy is a rarity ; so much so that many surgeons in a long and active practice have never had an opportunity to attempt this method. It will be of interest, therefore, to relate here the history of a case in which the writer performed this operation, and a very unusually large amount of the bowel was excised. At the same time, the conditions which made this step the proper one will be indicated.

I was called to see Mrs. M—— in the evening of March 23, 1889. She is, as her daughters say, "at least fifty-five years of age ;" has had a rupture twelve years, for which she has worn a truss. Twenty-four hours before my visit, while sweeping, she was taken with severe pain in the region of the rupture. The truss frequently allowed the gut to descend, and now she could not reduce it. Vomiting immediately set in. Her family physician now attempted taxis, failed, used morphine by needle, and ordered a poultice.

Four hours previous to my visit the vomiting, which had persisted and was frequent, became fæcal in odor ; and about that time, too, hiccough began and was very distressing. The local pain and tenderness continued.

On examination I found a hernia on the left side, about the size of a large fist, painful and tender, very tense, and without impulse on coughing. Gentle taxis failed. Poupart's ligament seemed to pass about to the middle of the tumor, and, the parts being quite fat, I was in doubt whether I had to deal with a femoral or an inguinal hernia. The most *fixed* point of the swelling seemed the lowest, which fact pointed toward femoral ; and its bulk seemed a little nearer the mid-point of Poupart's ligament—a little farther outward from the symphysis pubis—than would be the case with a complete inguinal rupture. Incision subsequently verified the assumption of a femoral hernia. The patient's general condition was fairly good. The temperature was 100.5° F. Her heart and kidneys seemed sound.

I advised immediate operation, to which she assented. The operation was begun two hours later, at 10 P.M. I was assisted by Drs. F. A. Manning, H. J. Kelly, J. H. Brower Browning, and two of my students, Messrs. Brickner and Van Deusen. I consider the good result obtained to have been largely due to the scrupulous care and attention of the surgeons named.

As the first step the bladder was emptied ; then the entire pubic and inguinal region and both labia majora were shaven, and the parts disinfected with ether and with a solution of bichloride of mercury, 1 to 2,000. A folded bichloride towel was packed into the slit of the vulva, and all the regions with which the hands of operator or assistants or instruments of any kind could possibly come in contact were covered with towels wrung from the bichloride ; so that the only exposed surface of skin was a space about the hernia six inches by four.

I considered it very important to have a high atmospheric temperature. There was no stove or other heating appliance, nor any atmospheric thermometer as a guide. I had the windows closed, and lit many lamps and swollen. The air was kept so warm that everyone present perspired freely.

An incision was made, in the long axis of the tumor, its entire length. The sac upon being exposed was of course freely incised, a grooved director being used to enlarge the original small point of incision.

The moment the sac was opened a considerable mass of omentum protruded, and a small quantity of fluid of offensive odor escaped also. A very loop of the small intestine was found strangulated, almost black in color, and tense with gaseous and semifluid contents. Its peritoneal coat was smooth in most places, but there were a few small ruptures of this coat, possibly due to taxis. As was subsequently discovered, a small ulcer at the point of constriction, of some depth, threatened perforation, and a deep groove in the gut separated the sound from the ulcerated portion.

The constriction was very great—it could scarcely have been greater. To relieve it I used, as the safest means that could be employed, the smaller blade of my French blunt-pointed scissors, curved on the flat and rather dull. This was cautiously introduced, the convexity toward the gut, and then, the edge being slightly turned toward Gimbernat's ligament, this was divided a sufficient distance to make circulation through the intestinal vessels entirely and easily possible.

Although the gut was not entirely lustreless, and was not sticky, I was convinced that it was dead. Upon pressing the gut sharply after freeing the constriction there was no peristalsis, and the very dark blood squeezed away by the finger and thumb did not return, even slowly. I determined to give it a chance, however, and nearly twenty minutes were spent awaiting a change in its color, the gut and the entire wound being meanwhile enveloped in soft cloths wrung out of warm bichloride solution, 1 to 10,000.

At the end of this time no change whatever was noticed, either in the gut or in the color of the mesenteric vessels supplying it.

Under ordinary circumstances I should now have considered excision and a temporary artificial anus the best of the several means at our disposal.

For three reasons I decided in this instance to follow my kelotomy by immediate circular enterorrhaphy. *First*, my patient was in excellent condition, and could, I thought, under the careful anæsthesia then being conducted, bear a much longer operation. *Second*, the appearance and feel of the gut, with which I have had many opportunities to familiarize myself, convinced me that it was a part of the jejunum and not the ileum, and hence nutrition with an artificial anus would not be well maintained. *Third*, the patient's bowel above the strangulation could not contain much fæces, as a thorough movement had occurred a little more than a day previously, and nothing had been retained in the stomach since then. Consequently, great pressure from retained gut contents would not be brought to bear against my intestinal sutures.

My first step was to ligate off with catgut the masses of omentum present, cut them away, irrigate carefully, and return the stumps to the abdomen. Next several inches of healthy gut at each end of the dead loop were drawn out of the abdomen. The gut, its mesentery, and the wound were thoroughly irrigated. In order to protect the peritoneal cavity from infection, a long strip of iodoform gauze was packed around the gut, in the bottom of the wound, as firmly as was thought safe for the vascular supply. Then the mesentery was stitched, with continuous sutures of catgut, a distance exactly equal to that of the gut about to be removed, and on a line about two-thirds of an inch from the gut. This suture puckers the mesentery so that it is greatly shortened. Then the gut was cut with scissors, which next divided the mesentery as close to the suture as seemed safe. Not only the dead bowel but an inch or more of that which seemed sound was removed from each end, the gut being really in the line of union rather than of [illegible]. The amount removed in this way measured [illegible] inches. This I have preserved, together with a part of the omentum excised. An additional small piece of the bowel was cut away at one end in order to make absolutely sure of perfect blood-supply from the mesentery there; so that a foot and about an inch of intestine were lost to the patient.

(This—if we accept as correct the lists of published cases, one hundred and fifteen in number, recently so carefully collected and classified by Dr. A. J. McCosh, of this city, and which specify death or recovery, giving details of the cases, including his own—is the largest amount of gut successfully removed at an herniotomy operation for strangulation on record in America, and though not by a few instances the largest in the world.)

This point regarding the blood-supply of the gut ends is of extreme importance. The severed gut must not project even a hair's-breadth beyond the cut edge of the mesentery, otherwise its life is threatened because of the peculiar anatomical distribution of the arterial supply.

One of the surgeons present now held the intestine firmly, so as to occlude it, about two inches from either end. These two inches were carefully emptied and irrigated, and then the ends were approximated. The sutures employed were of catgut, and interrupted. Two rows were used: a Czerny (embracing the muscular mucous coat) and a Lembert (covering and embracing the peritoneal coat). In sewing the muscular-mucous layer especial care was devoted to the intermesenteric margin. This, for ease of work, should be sewn first of all. I placed a mesenteric stitch tied but lightly across the gap above the gut, on each side, to reinforce this weak point. The Lembert sutures, following Sir William MacCormac's wise advice, were so drawn as not to press the peritoneal surfaces together, but barely to appose them. I remembered, too, Dr. J. A. Wyeth's report of a case of his own, demonstrating that within three hours and a half after the operation the line of contact was completely sealed, hidden, and protected by a thick layer of fibrinous exudate.

The stitches were placed ⅛ inch apart, and were not superimposed, so that a suture was present, of each alternate kind, for each $\frac{1}{16}$ inch. The needle used was a common small cambric needle which had been passed through a flame.

After a final irrigation with warm 1 to 4,000 bichloride solution, the gut was returned to the abdominal cavity. The hernial sac, in accordance with the method of Mitchell Banks in femoral cases, was now dissected clean away, clear up to Gimbernat's ligament; the freshly irrigated wound was dusted well with iodoform, and rather firmly packed with iodoform gauze, which was carried up as far as the peritoneum; and a stout bichloride-gauze dressing was applied. The duration of anæsthesia was two hours and three-quarters, of which nearly an hour and a half was devoted to work on the gut and mesentery.

The patient stood the operation remarkably well. There was very little shock, and the vomiting and hiccough ceased immediately, as also did the abdominal pain. A hypodermic injection of morphine with atropine was administered at once. No food whatever was allowed for twenty-four hours, and but little water; thereafter, but clam juice for the second twenty-four hours; then such as peptonized milk and Rudisch's sarco-peptones at the patient's option, for the first week, but no other food until after that period. The bowels moved spontaneously and painlessly the second day. (This was especially noted, for such cases.) I have since twice moved them freely by a glycerine enema; but usually she has a satisfactory daily movement without medication.

The temperature did not go above 101° F. (rectal), but remained between 100° and 101° for five days; after this it became normal. The dressing was first changed a week after the operation, because it had shifted a little, exposing the lower and inner angle of the wound. Under irrigation the packing, even the deepest, came away almost without pain. Her hips being elevated, the irrigating fluid still filled the wound and did not run into the abdominal cavity—showing that an exudation had covered and sealed the peritoneal opening. Probably it was this localized necessary and aseptic peritonitis which had caused the slight elevation of temperature mentioned.

The wound was completely healed about a month after the operation. Two weeks later the patient was allowed to get up, without a truss; which, it is hoped, may be permanently abandoned. The wound healed thus gradually, because of the repeated firm packings, preventing rapid filling. Thereby the cicatrix becomes denser and more resisting than would otherwise be the case.

It is not my intention to discuss the relative advantages of the dozen or more methods of suturing gut; these are elaborated in most systematic treatises on surgery, and are constantly receiving additions in recent writings. If simple circular enterorrhaphy is to be done without rings or other aids, it seems to me that no method combines speed with safety to a greater degree than the Czerny-Lembert, and yet its speed is all too little in most cases.

A word with regard to sutures and ligatures. I used catgut, and it has been used a number of times, notably in two recent instances reported by Dr. C. K. Briddon. But I think most surgeons advocate silk boiled in an antiseptic solution. My catgut was taken direct from the liquid which I have employed of late, and which I think keeps the gut aseptic and strong in a very satisfactory way: namely, a saturated solution of bichloride-washed iodoform in sulphuric ether. The raw commercial gut is first immersed in ether to remove its fat; and after a few days is put permanently in the iodoform-ether. Although the "iodoform question" is yet unsettled, still, because of Dr. G. de Ruyter's demonstration that a solution of iodoform in alcohol and ether is capable of penetrating tissues better than one in ether alone, I shall hereafter add alcohol to the iodoform-ether. I doubt, however, if it is much of an improvement on the simple ethereal solution, since the fact that ether can extract all the oil from the catgut shows its penetrating power in this instance; and because iodoform is much more soluble in ether (1 to 5.2) than in alcohol (1 to 80). Of course, the *solution* in either case does not reach the tissues to be sewn or ligated, as the gut taken out for use becomes dry almost at once.

Dr. Nicholas Senn's demonstration—that by the time forty-eight hours have elapsed after the gut is sutured, the cementing of the apposed serous surfaces is so great that even severe internal pressure will not part the lips of the wound—gives me confidence that there is no danger that the catgut will be absorbed too soon. And yet one has a greater feeling of security when aseptic silk is used.

In the case just related, the writer was bothered a little by the fact that so much intestine was removed that there was quite a noticeable difference in the calibre of the two ends. Beginning at the intermesenteric point and working round gradually with the sutures, there was a little wrinkle in the larger end to overcome before completing the circle. In a future case this would be avoided by putting the second stitch just half-way round the circumference, the third and fourth midway between these, and so on. In other words, it should be sewn according to the rule in other wounds—always dividing the spaces into halves, by our stitches. After doing this completely by the Czerny method, the peritoneal stitches could easily be placed in any order.

For microscopical purposes it is very proper to distinguish all the coats of the gut; to describe in their order the peritoneal, the longitudinal and circular muscular coats, the submucosa, the muscularis mucosæ, and the balance of the mucous layer. But it is as well to explain, for the benefit of those who have never worked on the gut, and who do not get a clear idea from their books on this point, that in the small intestine, at least, there are, for us as practical surgeons, only two layers which we can distinguish during operations: A thin outer layer, the peritoneum, which retracts quite a little when cut, and a thicker layer, including everything else. And in some portions of the small intestine—especially the lower part of the ileum—the entire thickness of the gut-wall is so trivial that the wall is quite translucent.

To prevent danger of tearing out, the Lembert sutures should pass a little into the layer beneath the peritoneum. We do not stitch directly through the intestinal walls for fear of fæcal material following the track of the thread, by capillarity, and infecting the peritoneum.

It is important to be able to recognize the region of the alimentary canal to which a given prolapsed and necrotic loop belongs, both for prognosis and because—as in the history just given—it may affect our choice in selecting the proper operation. The colon and the cæcum require no discussion; the bands of the former and the size of the latter settle the question at once. But in the small gut there are four points which guide us somewhat toward a correct conclusion: (*a*) The diameter of the jejunum averages ¼ inch more than that of the ileum—1½ inch for the former, 1¼ for the latter; (*b*) the jejunum feels decidedly thicker than the ileum, both because the former has an abundance of valvulæ conniventes and because its walls are actually somewhat thicker; (*c*) if the excised piece be split open the presence or absence, relatively speaking, of these valves will be a guide; (*d*) Peyer's patches being so much more numerous as we go down toward the distal end of the ileum, if the excised loop contain a patch, and if it be oval rather than round, this points to the ileum. The paler color of the ileum in the normal state is, of course, no guide in strangulated hernia, and the relative thickness to the feel would only be decisive to one familiar practically with the difference in this respect.

The points given can hardly help us *always* to distinguish different parts of the small intestine, but they mark quite sharply the characteristics of the duodenum and upper part of the jejunum as contrasted with the lower part of the ileum.

In the case under discussion the great length excised precluded the possibility of taking a V-shaped piece out of the mesentery; and, indeed, I cannot see the advantage of doing this in any case. The stitches might cut off some of the blood-supply to the gut-wound; moreover, the time spent in coaptating and suturing the edges is a needless prolongation of the operation; and so, I think, is the suturing of these mesenteric edges after cutting between the cobbler's sutures and the gut.

It seems best, by way of preventing bleeding, to make these latter stitches *before* dividing either the intestine or its mesentery.

There is a suggestion regarding irrigation which may perhaps not come amiss. This, I think, should be nearly continuous during the sewing, and of simple warm water, or better, because even less irritating, weak salt water—of a temperature of *at least* 100° F. If very distinctly warm to the hands, say 105° or 110°, the additional warmth will only have the soothing effect of a poultice; while, on the other hand, the slightest chilling or drying of the gut would tend toward shock. For the same reason, I think the heat of the operating room, previously mentioned, to be essential in cases demanding exposure of the bowels.

In another instance, perhaps, I should scratch lightly with my needle the peritoneal surfaces to be apposed, in order to hasten agglutination, as recommended by Senn. This I did not think of at the time.

Turning now to the question of radical cure of hernia—this naturally presents itself, following a discussion of the proper treatment of strangulation; for, whenever the patient's condition will permit it, an attempt should always be made to effect a complete cure, as a part of the same operation which relieves the constricted gut. It is hardly profitable to quibble over the question whether a "radical" cure is really possible. Most surgeons believe that it is possible in a majority of cases, and, at the worst, the truss which a returning rupture may necessitate will only need to be a light one. Whether or not it is wisest for the convalescent from a radical operation to go unsupported by a truss is still an undecided point. The greater number of surgeons approve of the truss here. Those who object to it think that the constant pressure of the pad tends to thin the walls and weaken the muscles about the inguinal canal. My own impression is that two factors should guide us. The question of strain ing, and the dangers of recumbency during convalescence. Those whose work does not demand muscular effort nor stooping, and who have not a chronic cough, nor obstinate constipation, and those who have been able to spend two or three weeks in bed after their wound has healed, thereby allowing a greater consolidation of newly healed tissues before they are subjected to tension—these are they who should be permitted to discard all support, whether of truss, pad, or simple bandage.

Several of the modern methods whereby radical cure is sometimes effected have been fully discussed in a preceding volume. Spanton's corkscrew and Wood's subcutaneous suturing have not found much favor in this country, perhaps because they are not daylight methods. Heaton's method, by astringent injections, is unscientific: it does not obliterate the sac, and merely condenses and shrinks the tissues about it, thereby narrowing its calibre. This scar tissue, under constant pressure from above, will probably not be permanent. In the hands of a surgeon, other methods will lead to much more brilliant results. Among those who fear the knife, Heaton's method will often palliate and sometimes cure. The cutting operations for this purpose, in careful and judicious hands, are not serious in prognosis. Dr. Macewen has reported a series of eighty-one cases without a death. In twenty-nine of these strangulation had been present.

Perhaps the following plans are at this day those most in vogue among surgeons, in attempting radical cure of inguinal hernia: *A.* The methods of Czerny, Banks, Nussbaum, and Socin. *B.* Those of Bassini and Barker. *C.* That of Ball. *D.* That of Macewen. *E.* That of McBurney.

In all of these and, in fact, in any modern scientific attempt to effect a cure here, the treatment of the sac is the essence of the whole matter. If this is not completely obliterated,—if any peritoneal depression or pouch, however small, is left at the deep ring,—then the method, whatever it may be, will probably prove an ultimate failure. The gut or omentum will descend again, little by little, pushing its pouch, the sac, before it.

Before describing individual methods, it may be well to say a word or two regarding the situation of the rings, and our anatomical guides thereto. The deep ring lies just above the middle of Poupart's ligament, and almost directly over the sheath of the external iliac or common femoral vessels; that is, a line at right angles with the ligament would cut the middle of both sheath and ring. This point is easily made out, as Poupart's ligament ends at a distinctly felt spinous process, above and below. The statement here made does not agree with that in the anatomical text-books, which puts the deep ring midway between the anterior superior spine of the ilium and the symphysis (not spine) of the pubes. A series of dissections, however, has convinced me that normally the middle of this ring is over the *middle* of Poupart's ligament. In old oblique hernia, however, this ring is so dragged down toward the superficial one, and the inguinal canal is thereby so shortened, that sometimes there is actually no lateral difference between the seat of the deep ring and that of the superficial one; and this fact, of course, renders a radical cure very difficult of accomplishment, as the path for passage of the gut would then be very short, direct, and easy.

To find the superficial ring, feel for Poupart's ligament, which can be rolled under the fingers and cannot be mistaken. Follow this downward and inward, and it will be found to end at a distinct spine—that of the pubes. In fat subjects if the spine is not readily felt at first, press very firmly and steadily, and the adipose tissue will melt away to either side of the finger, so that in a minute this bony point is easily recognized. The superficial ring is always found just above the spine, extending half an inch or so both outward and inward. And the inguinal canal connects the two rings, lying just above Poupart's ligament.

My reason for giving these latter and familiar facts in this way is, that in so many works on operative surgery a number of measurements are recommended to enable one to locate the superficial ring. If these are accurate it will be found, after the spot is carefully located thereby, that it exactly overlies the easily felt spine of the pubes. Therefore such rules are quite unnecessary.

It is assumed—if we are not operating for strangulation—that the patient's bowels have been moved, and preferably with calomel, which is most thorough and not irritating; also, that the bladder is emptied; and also the parts are shaven and disinfected. The thigh should be slightly flexed, and a free incision made, the mid-point of which is over and somewhat above the superficial abdominal ring. The skin is retracted downward. By this little point of Mr. Kendal Franks', the skin wound does not correspond with the line of buried sutures, and is somewhat further removed from the region of possible urinary or fecal contamination. So much for rules generally applicable.

A. The sac is now exposed, opened over a moderate extent to make sure that there are no adhesions within, for it must be completely empty. Should adhesions or omental masses be found, the treatment should follow the lines already formulated in discussing strangulation.

If the hernia be found to belong to the congenital type, so that the finger passed downward in the sac feels it to be a tunic of the testicle, then the sac should be severed a little above the testicle, the lower part being closed by sutures to make a tunica vaginalis.

For irrigation within the sac, warm Thiersch's solution—the boro-salicylic—is excellent, being unirritating. Care should be taken, if work upon the sac contents is necessary, to prevent blood and irrigating fluid from entering the abdominal cavity, by packing a small aseptic sponge, controlled by a catgut or silk cord, into the neck of the sac, for the time being.

By careful blunt dissection the sac should now be detached completely from its surroundings, and cleared up to the deep ring, being pulled as far as possible out of the inguinal canal. The hard feel of the vas deferens is a guide in separating the cord from the sac. Sometimes, even with exercise of the greatest care, where firm adhesions exist between the cord and sac, the vas has been cut. Dr. A. G. Gerster has reported such a case. Recognizing the nature of the accident, he adopted, as an ingenious expedient, an attempt at restoration of continuity. "A short piece of stout catgut was introduced into the patent ends of its lumen, and the duct was united by four fine catgut sutures."

The detached sac is now ligated firmly—with chromic gut, aseptic silk, or simple stout aseptic catgut—at the highest point at which the ligature can be applied; the fundus is divided about half an inch below this point and removed, and the stump is pushed well up into the deep ring. To prevent slipping of the ligature, some surgeons when tying transfix the sac with a double thread, ligating off the two halves separately.

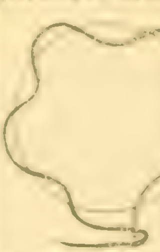

FIG. 2596.—Purse-string Suture employed for closing the neck of the hernial sac. (After Gerster.)

Dr. Gerster has suggested and practises, instead of the ordinary method, the purse-string suture. The technique of its application is clearly seen in Fig. 2596, taken from his work on Surgery. This suture, while completely shutting off the peritoneal cavity, does not entirely prevent circulation of blood in the short stump left after section of the sac. That this shall live is an obvious advantage.

The subsequent steps of method *A*, after dissecting out, tying off, and cutting away the sac, have for their object the narrowing of the inguinal canal. The surgeon has to pass a suture through (1) the conjoined tendon and external oblique aponeurosis on the one hand, and the mid-point of Poupart's ligament on the other, or as near the middle as possible. This stitch, bringing outward the conjoined tendon, is a very important one in helping to restore the normal valve-like action here. In passing it, avoid including the deep epigastric or external iliac vessels, or the spermatic cord. (2) A suture a little lower, through the conjoined tendon and external pillar of the superficial ring. (3) A stitch through both pillars of this ring—and so on. The stitches are placed at intervals of about one-third of an inch, and usually from four to seven are used. The material employed by Mitchell

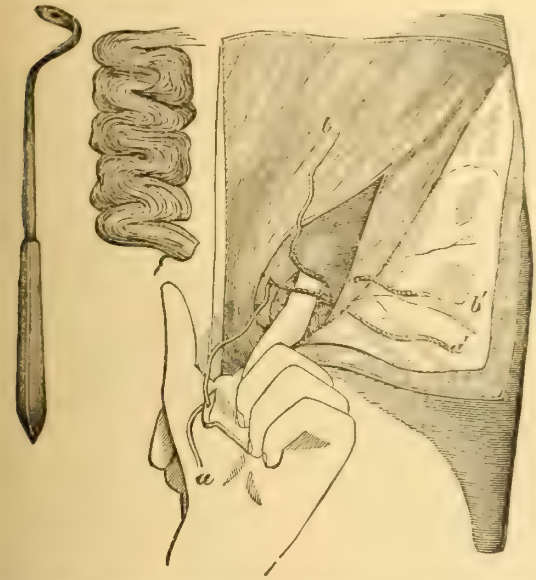

FIG. 4894.—On the left is one of Dr. Macewen's needles; they are made of one piece of steel. In the middle is the folded sac. The right-hand figure (modified from those of Dr. Macewen) is intended to show his mode of suturing the internal ring. The index-finger in front of the folded sac is separating the peritoneum round the internal ring. The suture *a*, *b*, has penetrated the conjoined tendon at two places, first from without inward near its lower border, and secondly from within outward, as high up as possible, a loop being thus left on the abdominal aspect of the conjoined tendon. At *a'* and *b'* the two ends of the above suture have been passed, separately threaded on needles, from within outward, through Poupart's ligament below, and through the transversalis and obliquus above. (Copied from W. H. A. Jacobson's "The Operations of Surgery.")

Banks, preferably, is silver wire, so thick that a single knot will hold, with the ends cut close, and without any twisting or any second knot; silk is his second choice. Czerny differs only in that he prefers silk for his sutures. Macewen advocates the chromic acid gut so prepared as not to be absorbed short of from fourteen to twenty-one days. The stitches should all be introduced before tying any of them. Finally tie them, beginning with the highest and going downward in order. Before tying each and every stitch, the cord should be examined and left free. Drainage is accomplished by means of a small rubber tube (Czerny), or a bundle of horse-hair (Banks), or a decalcified chicken-bone tube (Macewen); and finally the skin-wound is coaptated and sutured.

B. The method of Riesel and of Barker. Here the incision, as before, exposes the superficial ring freely, and Riesel also splits the anterior wall of the canal clear up to the deep ring. He then ties the neck of the sac at as high a point as possible. The fundus of the sac is left *in situ*, helping to make a resisting mass here, its cavity being obliterated. Part of the anterior wall of the canal is cut away; transverse deep sutures are introduced, in much the same manner as in method *A*, but beginning high up, at the deep ring; and finally the skin is sutured.

Barker does not split the anterior wall of the canal. The sac is separated at its neck, and tied opposite the superficial ring. Its neck and the stump are drawn up the canal and against the deep ring by means of threading needles on the ends of the ligature about the sac, and passing these, guided by the finger, each along the canal, and then through the aponeurosis of the external oblique at points opposite the borders of the deep ring, where they are tied. Three or four more deep sutures, again of silk, are passed across the walls of the canal, high up, and across the borders of the superficial ring, all sutures being superficial to the spermatic cord. This method resembles that of Riesel in that both, after tying off the sac, leave the lower portion of it in the canal permanently.

C. The method of Mr. C. B. Ball consists in stitching the twisted stump of the sac to the pillars of the superficial ring. The sac is, as in Czerny's method, isolated clear up to the deep ring, is ascertained to be empty, is seized by a pair of wide-jawed forceps at its neck, and gradually and gently twisted. On the average, four or five entire revolutions are enough; but his rule is to continue torsion until it seems as if further attempts would cause a rupture. By this time the peritoneum beyond the deep ring will probably have been included somewhat, and a laparotomy would show curved lines of peritoneum radiating from the internal ring.

The twist is now maintained while the neck of the sac is ligated with stout catgut, and while two strong silk sutures are passed through it distally to the ligature. These stitches are each made to include the inner and outer pillar of the superficial ring, and come out through the skin half an inch from the wound. The sac cannot now untwist, and it is cut away distally to the sutures just named, which are next tied over lead plates, so placed as to relieve the skin tension.

Objections to this method would seem to be the possibility of twisting in a small knuckle of gut adherent at or near the deep ring, and a possible peritoneal rupture from slight excess of twisting.

D. The method of Dr. William Macewen is the one which is now most employed, at least in this city. Of all the longer lists of published cases reported by various operators, his statistics as to success have been the most brilliant. Stated briefly, his method consists in retaining the entire sac, detached as far as to its neck, and crumpling it into a wad which is forced against the deep ring and left there; the canal and the superficial ring being at the same operation narrowed by suture.

Dr. Macewen freely exposes the superficial ring and the sac below this. He dissects out and examines the sac as described in method *A*, but any adherent connective or adipose tissue is carefully preserved as a part of the sac mass, which makes therefore a larger plug than would otherwise be the case. The sac is not only stripped up to the deep ring, but the peritoneum around that ring is also separated for about half an inch.

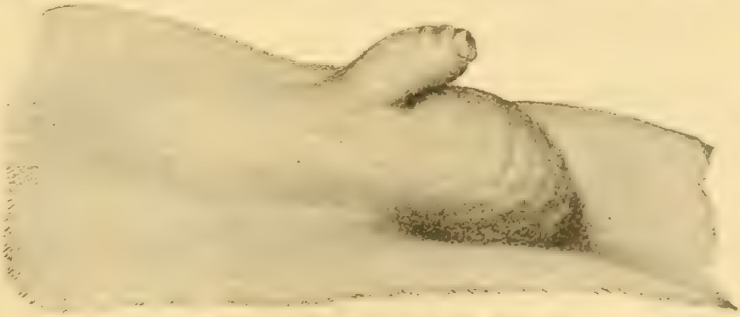

FIG. 4895.—Copied, by permission, from McBurney.

A stitch is now secured firmly into the distal extremity of the sac, and then passed, in a proximal direction, several times through and through the sac (backward and forward, like a shuttle); so that, when pulled upon, the sac becomes folded on itself like a curtain, constituting a pad (see Fig. 4894). The thread is now attached to a hernia needle, or any long, slightly curved needle,

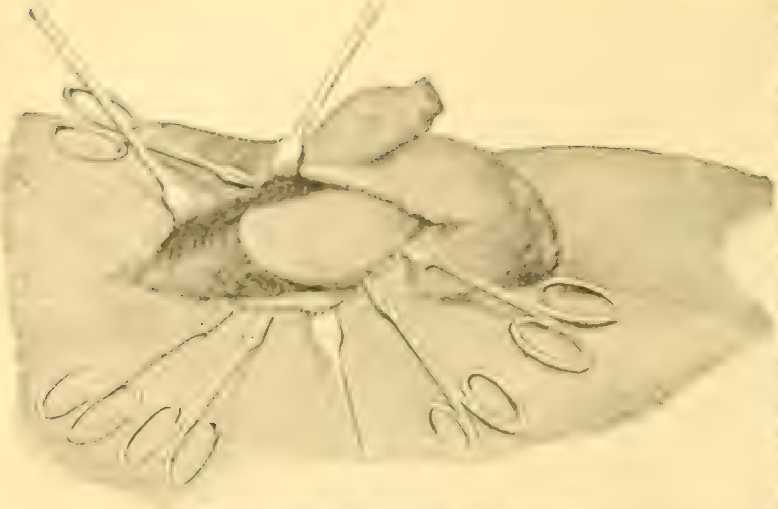

Fig. 4896.—Copied, by permission, from McBurney.

which is carried up the canal and brought out through the abdominal muscles at a point one inch above the deep ring. By pulling up the sac the point of the needle comes out of the muscles just below it—that is, without penetrating the skin.

By pulling on this suture the folded sac is drawn up the canal and through the deep ring, forming "a boss or bulwark" on its peritoneal aspect, which projection is intended to shed to either side the intestinal waves of peristalsis.

Next, the thread is secured by a few stitches taken in the external-oblique aponeurosis, or else by tying over a bit of decalcified bone drainage-tube.

Finally, the freshened canal is narrowed, and the action of the conjoint tendon as an obturator restored as much as may be, by sewing this to Poupart's ligament at a point on the latter as far out toward the anterior superior spine of the ilium as is possible, and also to the transversalis and oblique muscles here. The rest of the canal and the pillars of the superficial ring are also sewn, as detailed in method A. The peculiar method of inserting these first stitches is illustrated in the cut, which also shows one of Macewen's needles for this purpose. These are made with the curve turned either to the right or to the left. While a convenience, they are not a necessity for the proper performance of the operation.

Macewen applies a sublimate gauze and wood wool dressing. "As a rule a portion of elastic webbing is placed over the margin of the pad and stretched to secure it firmly." The patient, in bed, has the shoulders and knees slightly raised to relax the tissues about the canal. The dressings are not disturbed until two or three weeks later, unless stained, or when the patient shows an abnormally high temperature.

When they are removed the wound is found healed; but a fresh pad is applied to continue pressure. The patient is allowed to get up in from four to six weeks after the operation, but does no work until the end of the eighth week. Lifting or straining is permitted only after the third month. Adults engaged in laborious occupations are advised to wear a belt; and elsewise, only in the case of those "of very lax build."

The writer has used this surgeon's exact language in several parts of the foregoing description.

In children, and occasionally in other cases, the sac may be so thin that it is impossible to make a clean and unbroken dissection of it as above. It may be gangrenous, or otherwise unfit to use. Sometimes, too, the entire bulk of the folded sac is quite too small to plug at all effectively the internal ring. In cases of congenital hernia this is apt to be true, as the lower part of the sac must remain to form a tunica vaginalis.

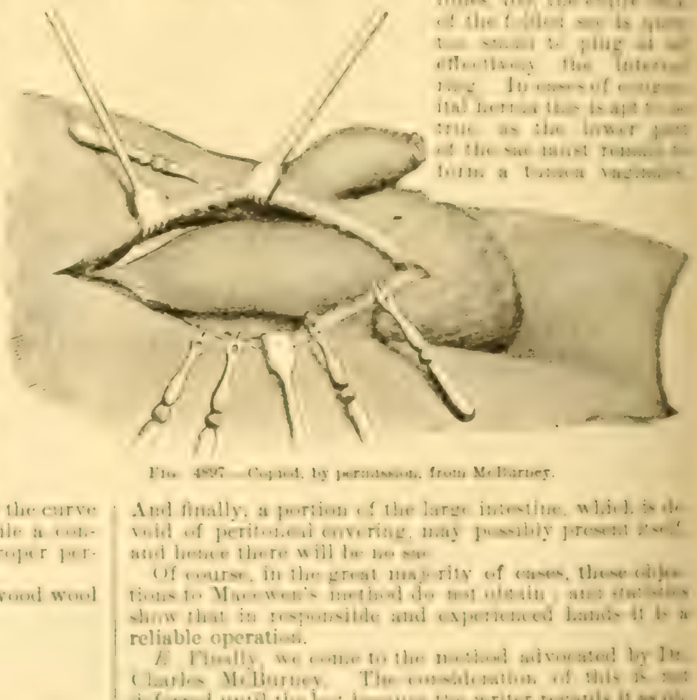

Fig. 4897.—Copied, by permission, from McBurney.

And finally, a portion of the large intestine, which is devoid of peritoneal covering, may possibly present itself, and hence there will be no sac.

Of course, in the great majority of cases, these objections to Macewen's method do not obtain; and statistics show that in responsible and experienced hands it is a reliable operation.

E. Finally, we come to the method advocated by Dr. Charles McBurney. The consideration of this is not deferred until the last because the writer regards it as objectionable. Quite the reverse is the case; and it is discussed later for the reason that it is of more recent date than any of those named heretofore. It has now had a fairly sufficient length of time in which to demonstrate its qualities, so that surgeons can better form a verdict. Dr. McBurney first devised and used it in 1888. Briefly stated, the steps are, entire removal of the sac at the peritoneal level, and open treatment of the wound, which after healing presents a thick scar to oppose return of the rupture.

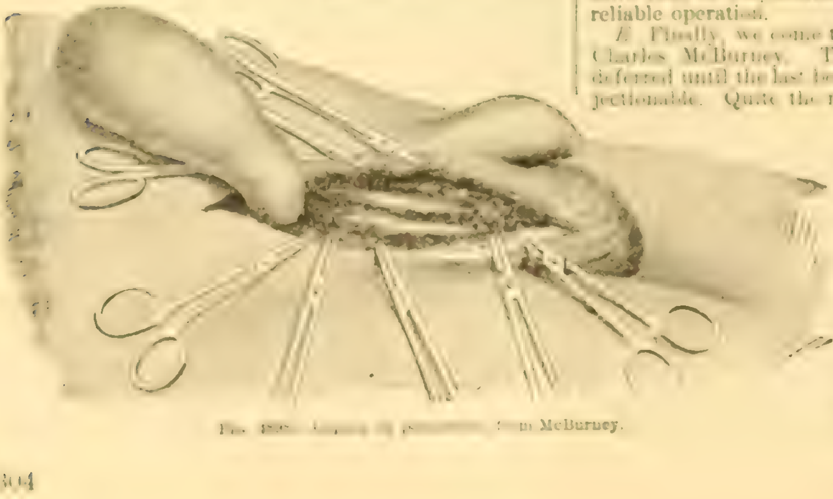

Fig. 4898.—Copied, by permission, from McBurney.

Dr. McBurney calls attention to the objections just mentioned regarding operations which we have discussed, and further points out the absurdity of attempting permanently to unite the pillars of the superficial ring by means of sutures. These pillars were never meant by nature to lie in contact; their edges also are too thin to readily unite. Permanent stitches holding them together are bound ultimately, if gradually, to cut through, allowing separation of the edges, and this will be hastened by every motion of the flat muscles of the abdomen. Further, such suturing offers no resistance at all against descent of a hernia through the deeper ring and the canal. Therefore, suturing, to be of any value, should mainly be of a nature to obstruct the pathway of the gut at its beginning; and Dr. McBurney claims that, by the blunt dissection of the sac always advocated, such surfaces as are coaptated by the buried sutures (the conjoint tendon and Poupart's ligament, for example), are not very likely to unite firmly. Further, assuming that they have so united, there is still a space above and to the outer side of the conjoint tendon which can offer no resistance beyond that of loose areolar tissue to a commencing new sac, caused by repeated impact from within. He thinks, too, that the great success of Macewen is due to perfect obliteration of the sac, rather than to successful obstruction from his sewing.

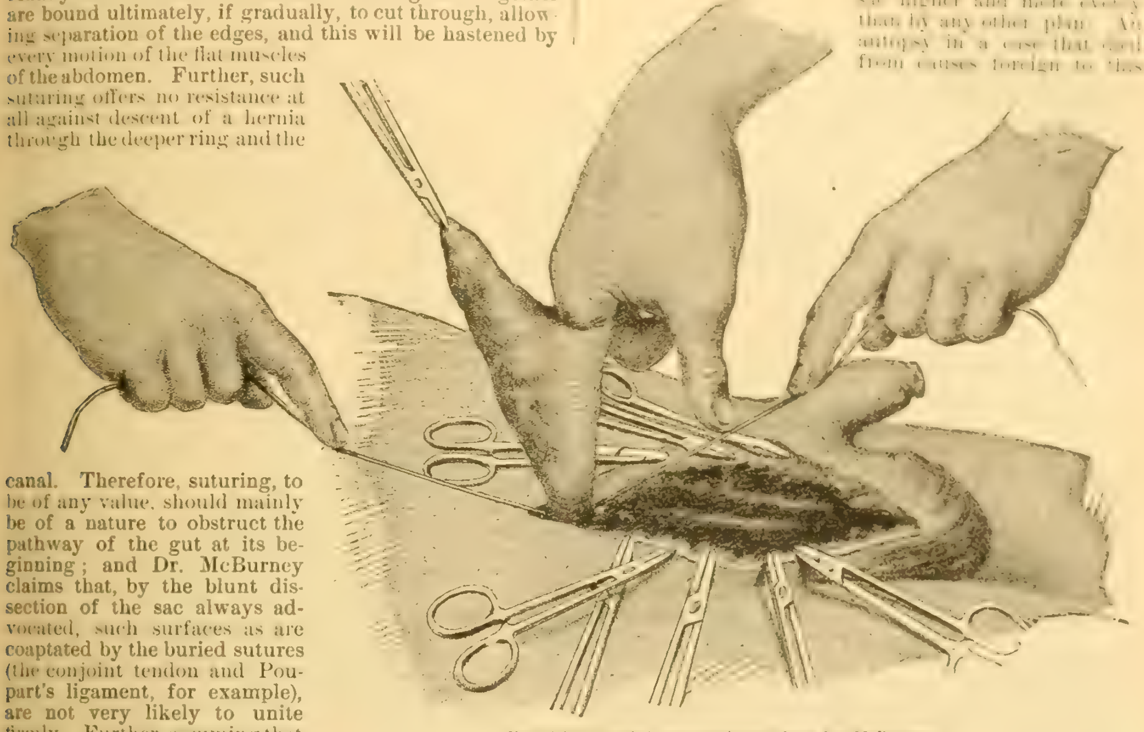

FIG. 4899.—Copied, by permission, from Dr. McBurney.

McBurney's incision begins a little *outside* of the deep ring, and is carried across the canal, the superficial ring, and a sufficient distance below (Figs. 4895 and 4896. These and the following cuts are used by permission).

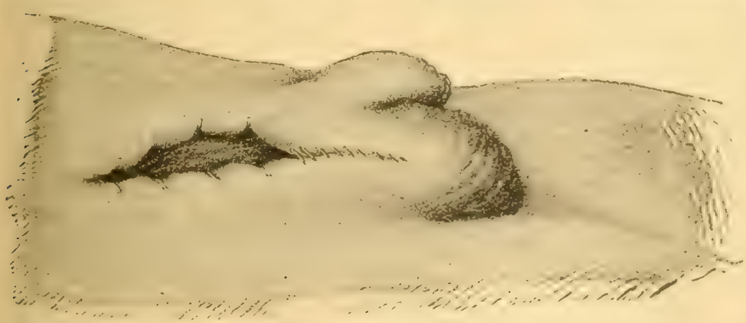

FIG. 4900.—Copied, by permission, from Dr. McBurney.

Following the method of Riesel, the aponeurosis of the external oblique muscle is cut, beginning at the superficial ring and running parallel with Poupart's ligament and a little above it, up to and slightly beyond the outer border of the deep ring, thereby opening the front of the canal from end to end (Fig. 4897.) This enables the operator to separate the cord from the sac with comparative ease, and the sac from its environment; and these steps should be begun high up and continued downward. It also enables the surgeon to strip with ease and safety the neck of the sac away from the abdominal walls for a short distance inside the deep ring (Fig. 4898), and to tie off the sac higher and more evenly than by any other plan. An autopsy in a case that died from causes foreign to this subject, some time after being subjected to this operation, showed, according to Dr. Abbe, who was present, a perfectly smooth peritoneum opposite the deep ring, marked by a punctate cicatrix only.

Prior to ligation—which is done with either stout silk or catgut—the sac is opened for examination of its contents, as heretofore described; and during ligation it is held vertically while the index-finger of an assistant is kept deeply in its neck, to prevent a nipping of the gut or omentum. The ligature is tightened over the tip of his finger, and flush with the general peritoneum (Fig. 4899), after which the sac is cut away as close to the ligature as safety will permit.

Dr. McBurney believes that a firm, deep, and solid cicatrix will offer the greatest resistance to return of the gut, and judging by analogy, there is no reason why it should not be permanent when once formed. He makes the two walls of his wound as nearly solid and homogeneous as possible, by from four to eight stout catgut or silk stitches placed on each side (Fig. 4900). These should invert the skin and go through *all* the abdominal layers down to the transversalis fascia, on their own side of the wound. Now, the wound must heal from the bottom. But it is too wide, and therefore two or more heavy sutures are placed across it, drawing the edges so that the average width of the space between the lips of the wound shall be from one-fifth to one-fourth inch. These last sutures pass down to, but not through the abdominal muscles, and are tied over pledgets of iodoform gauze, in order to prevent their cutting. The wound is now irrigated, dusted with iodoform, and packed firmly with absolutely gauze to the very bottom. This firm packing prevents an oedema, which otherwise occurs, and interferes with granulation. Fig. 2902 shows the wound packed and ready for the external dressing. The scrotal or labial wound is sewn without packing, and may be drained from below if thought advisable.

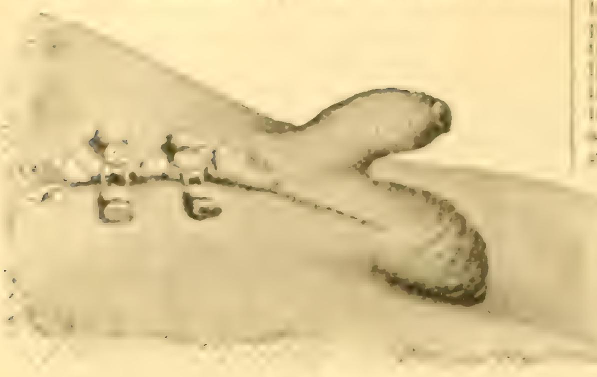

Fig. 2902.

An ample bichloride gauze dressing is applied and bound securely in place. A large square of rubber tissue, having a hole for the penis in its centre, is put in place just beneath the bandage. In women, especially, it is well to catheterize for some days to avoid risk of wetting the wound. In children, for the same reason, a shellac-coated plaster of Paris dressing is advisable. The dressing is changed and renewed as before, at the end of five or six days; subsequently every four to six days. The average time required for complete healing is from five to six weeks; at the expiration of which time the patient will have a very strong cicatrix; hence the delay for this length of time in bed is advantageous, enabling the subject to discard the truss altogether. In fact, Dr. McBurney strongly disapproves of the truss, believing that its constant pressure tends to cause weakness of the scar.

A theoretical objection to the operation under discussion would be that the spermatic cord might become constricted by pressure from the inevitable contraction of the scar tissue with which it lies in contact. As an actual fact, however, this has never occurred, and the cord takes care of itself.

The advantages claimed for this method are:

1. That in inguinal hernia one is able, after laying open the canal, very evenly and completely to tie off the sac, and so obliterate it.

2. That the wound being open, no drainage is required, and the risk of abscess and septic complications is reduced to a minimum. Since the great majority of deaths from attempted radical cure have occurred either from septic troubles or from hemorrhages, and since many men attempt cutting operations who are not entirely familiar with aseptic technique, this is undoubtedly the safest of the true radical operations.

3. That the walls of the canal are united throughout by strong cicatricial tissue.

4. That it is rapid, and applicable to every form of inguinal hernia.

I have gone much into detail here, giving often Dr. McBurney's exact language, believing that the method warrants it. Surgeons generally are regarding it at present with growing favor. And if used at all, it is simple justice to the method and to its author to employ it as he has directed.

Robert H. M. Dawbarn.

INTUSSUSCEPTION. History.—Obstruction of the intestine was known to the ancients, who grouped it with peritonitis and other affections giving similar symptoms under the name "Ileus." Thus Hippocrates speaks of εἰλεός, literally the Latin volvulus; but it is evident from his description that this name was suggested not by the anatomical displacement known to us as volvulus, or twisting of the bowel, but rather by the supposition that the disease was situated in the intestine, the peristaltic movements of which were already known. It may be, however, that the twisting character of the pain, or perhaps the visible peristalsis sometimes noticed in intestinal obstruction, gave the reason for the name. Aretæus limited the term εἰλεός to cases in which only the small intestine was involved, the similar affections of the large intestine being called by him χόρδαψος (χορδή, a string, and ἕψω, to boil, or ἅπτω, to bind). Galen, however, gave the latter name to those cases of εἰλεός in which a tumor could be felt in the region of the small intestine.

Intussusception was the first form of intestinal obstruction to be recognized pathologically, being first found by autopsy as early as the sixteenth century. We are indebted to Peyer,[1] Ruysch,[2] and Haller[3] for the first descriptions; and Peyer, at least, investigated the subject by experiments upon animals. Before their time, ileus had been considered a nervous affection, and this view is actually clung to by Hilliard as late as 1811.[4]

The form of intussusception which occurs in the death-agony, the "intussusception of the dying," was first recognized and distinguished from the clinical form by Louis,[5] Baillie,[6] and his translator, Soemmering,[7] and also to Voigtel,[8] who saw it in animals.

Laparotomy was performed for this form of obstruction at a very early date. In 1692 Nuck, a Dutch physician, caused a surgeon to open the abdomen of a patient and reduce an intussusception, with a successful result. In 1700 Bonetus also had a successful case of laparotomy for intestinal obstruction; but whether the form of obstruction found was intussusception is not beyond question. In 1810 Otto had a fatal case of laparotomy for intussusception, and in 1824 Fuchsius was able to save the life of a patient by operation. After that time the operation became much more common, and the writer of this article found seventy-one operations for intussusception among the 528 cases of laparotomy for acute intestinal obstruction performed from 1873 to 1887 inclusive.

In modern times the statistical analyses of Leichtenstern, Rafinesque, Treves, and Braun, and the monumental work of Nothnagel, are the most noteworthy contributions to our knowledge of this disease. These and others will be referred to in the course of the article.

Definition.—Intussusception has been variously defined, but to get a clear idea of all its aspects it is necessary to combine the different points of view taken by the numerous definitions. The old physician, Velse, defines intussusception as the disappearance of one part of the bowel into its adjacent part when it is driven into the latter ("Quum [illegible] impulsa [illegible] absconditur"). Gay describes it as, anatomically, an invagination; surgically, an internal hernia. Treves defines it as the prolapse of one part of the bowel into the lumen of an immediately adjoining part. Cruveilhier very happily compares it to a partial inversion of a finger of a glove.

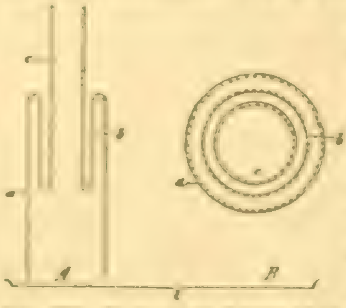

Fig. 2903.—Diagrammatic Section of an Intussusception. A, Intussusceptum; B, intussuscipiens; a, external layer; b, middle layer; c, internal layer.

The characteristics of the lesion can best be made clear by describing the way in which it can be produced in the intestine of a cadaver. One hand compresses the bowel so as to reduce it to the smallest possible bulk, and then thrusts it into the next adjacent part, held by the other hand in such a way as not to diminish its lumen. The compressed part is forced into the other as one would insert the fingers into a tight glove. An intussusception consists of three layers of intestinal wall (see Fig. 4902): the internal layer, continuous with the normal intestine at one end of the intussusception; the middle layer, where the wall of the intestine returns upon itself, being bent back outside of the internal layer; and the external layer, forming the sheath of the whole, and continuous with the normal bowel at the other end of the intussusception. The middle layer is continuous with the internal layer at one end, and with the external layer at the other. The peritoneal surfaces of the internal and middle layers are in contact, and the mucous surfaces of the middle and external layers, the middle layer being turned inside out, while the other two preserve their normal position in this respect.

The external layer or sheath is called the intussuscipiens; the two other layers, being contained within the external layer, are together called the intussusceptum. The apex is the free extremity of the intussusceptum which projects into the cavity of the intussuscipiens, and the neck is that part of the intussusceptum which is constricted by the edge of the intussuscipiens at the point where the middle layer turns back again to form the external layer or sheath. By some authors the constricting edge of the intussuscipiens is also included in the term neck, but if it is necessary to give a name to this part it should rather be called the collar.

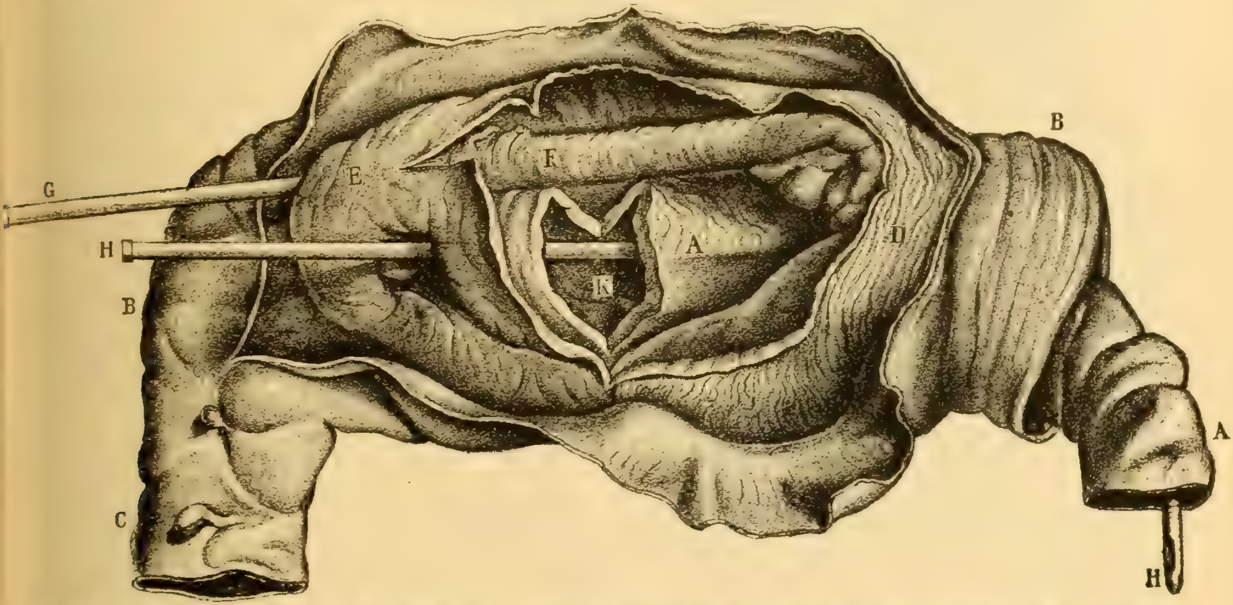

Fig. 4903.—Ileo-cæcal Intussusception. (From Rafinesque.) A, ileum; B, transverse colon; C, descending colon; D, ascending colon (mucous surface); E, cæcum (mucous surface); F, vermiform appendix; G, sound passed into the vermiform appendix; H, H, sound passed through the ileocæcal valve and the ileum; K, ileum, mucous surface exposed by incisions in the walls of the bowel.

It follows from this formation that there are two cylindrical spaces between the layers of the intussusception, one between the external and middle layers, lined with mucous membrane and continuous with the cavity of the bowel; the other between the internal and middle layers, lined with peritoneum, and continuous with the peritoneal cavity. In the space between the internal and middle layers lies the mesentery belonging to the loop of intestine that forms the intussusceptum, folded upon itself, and dragged in by the traction of the intussusceptum in its efforts to pass on down the bowel, and thus moulded into the shape of a cone, being thickest at the neck.

Frequency.—According to Leichtenstern, in 1,152 cases of intestinal obstruction, excluding congenital obstruction, stenosis of the rectum, and the various forms of hernia, there were 442 cases of intussusception, about thirty-eight per cent., so that this is one of the most frequent forms of occlusion of the bowels.

Varieties.—One of the important distinctions to be made in the classification of intussusceptions is that between the clinical or inflammatory intussusceptions and the intussusceptions of the dying, which form just as life is passing away. The clinical intussusceptions are also called inflammatory, because they almost invariably show some inflammatory changes when examined at autopsy, while the intussusceptions which form in the death-agony are entirely free from them. The intussusceptions of the dying are, of course, without clinical importance, but from an anatomical stand-point no difference can be found between them and the clinical form; and as the mechanism of their formation must be the same, they should be carefully studied for the sake of the light which they throw upon the etiology of the disease. The characteristics which serve to identify the intussusceptions of the dying at autopsy are their retrograde direction, the apex being turned toward the stomach-end of the intestine, their small size, their ready reducibility, as no adhesions are found, and their occurrence in considerable numbers. It is the rule to find several in one body, and exceptionally ten, or even more. As we shall presently see, the clinical intussusception is usually single, almost invariably directed toward the anus-end of the intestine, shows more or less marked changes from disturbed circulation, which render it difficult of reduction, and it may attain a considerable size.

The varieties of intussusception may be classified according to the part of the intestine which is involved. This anatomical classification divides them into those in the small intestine, enteric; those in the colon, colic; those in the rectum, rectal; and two forms which are found at the ileo-cæcal valve. If the valve retains its integrity, and is pushed forward into the colon at the head of the intussusception, we have the ileo-cæcal form, two subvarieties of which can be distinguished. In the more common of these subvarieties the cæcum becomes inverted with the valve, and assists in the formation of the middle layer (see Fig. 4903). In the rarer subvariety the inversion begins at the junction of the colon and cæcum, and the latter forms part of the internal layer, being advanced parallel with the ileum, and at the apex of the intussusception two openings can then be found, one being the ileo-cæcal valve, and the other leading into the cavity of the cæcum. This latter subvariety is so rare that it might almost be omitted from the list.

In the other form of intussusception, which occurs at the ileocæcal valve, the valve itself gives way, and the lower part of the ileum is inverted or prolapsed through it into the colon; hence it has received the name "ileo-colic" (see Fig. 3004). Leichtenstern and Treves suppose that the mechanism of the ileo-colic intussusception is the same as that of the prolapse of the rectum at the anus; but it is not clear why it might not also take place by the growth of an intussusception in the lower part of the ileum in the ordinary method—by simple advance of the apex of the intussusception already formed, forcing its way through the ileo-cæcal valve. But we shall return to this question when we consider the mechanism of intussusceptions in general.

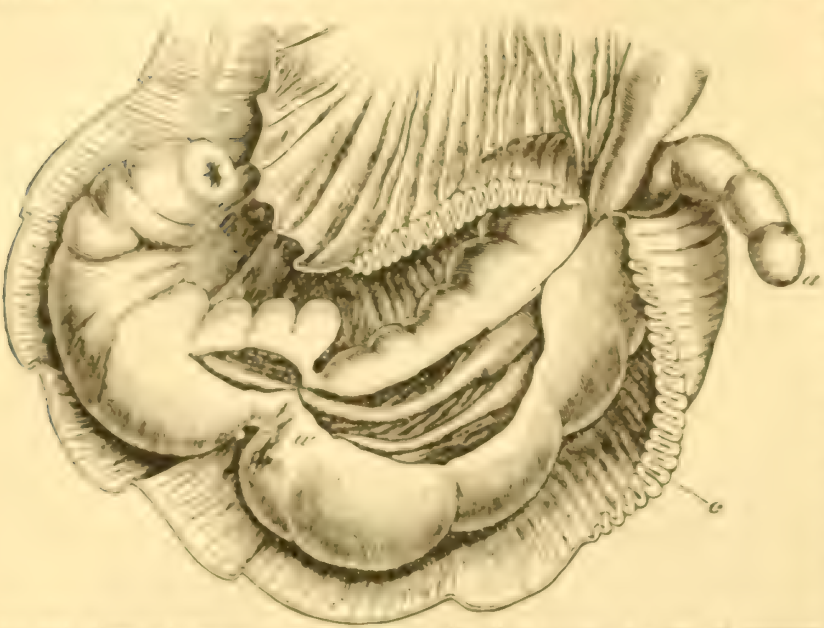

FIG. 3004.—Ileo-colic Intussusception. (From Treves, after Von Rokitansky.) a, colon; b, vermiform appendix; [illegible]

In the small intestine, intussusception is almost entirely confined to the ileum and the last part of the jejunum, being most frequent in the latter situation, according to Treves. According to Leichtenstern, they are most frequent in the lower ileum, and next at the ileo-jejunal junction. From the latter author we obtain the following table:

Relative Frequency of the Various Forms of Intussusception.

	Cases.	Per cent.
Ileo-cæcal	212	44
Enteric	[illegible]	30
Colic	90	18
Ileo-colic	39	8

These figures show that while nearly one-half of the cases are ileo-cæcal, and nearly a third are in the small intestine, but eight per cent. are of the ileo-colic variety. It is important to note that one case in twelve or thirteen is of the ileo-colic form, for the very existence of this variety was denied by many writers upon the subject before Leichtenstern's time. There are a few rare cases of intussusception of the duodenum on record.

FREQUENCY.—Among the predisposing causes of intussusception, its frequency in infants and in the male sex must be noticed. The statistics as to sex vary in their exact proportions, but the greater frequency of the disease in the male cannot be disputed. Thus Leichtenstern found it to occur 1.8 times in the male to once in the female, calculating upon [illegible] cases. Cox, in 1,280 cases, found the proportion 1.11 in the male to 1 in the female; but during the first year of life the proportion was 1.8 to 1, the figures growing gradually more equal as adult age was approached. Rafinesque, in his collection of fifty-one chronic cases, found intussusception to occur in males three times as frequently as in females, which is all the more remarkable as the proportion of adults is so great in this class of cases. It need scarcely be said that no reason is known for the greater liability to intussusception upon the part of the male sex.

Age is a still more important factor in the predisposition to intussusception. During the first three months of life intussusception is extremely rare, but in the second three months it is more common than at any other period of life. Leichtenstern found that twenty-nine per cent. of his cases occurred before the first year of life had passed, and forty-six per cent. before the eleventh year, while thirty-six per cent. of the entire number of cases were between eleven and forty years of age, and only sixteen per cent. over that age. Treves gives some figures of the relative occurrence of the acute form at various ages, obtained by a comparison of the results of various statisticians; and adding to them Rafinesque's figures for the chronic variety of intussusception, calculated upon 51 cases, we obtain the following:

Frequency of Intussusception at Various Ages.

Age.	Acute cases.	Chronic cases.
	Per cent.	Per cent.
Before 11 years	[illegible]	[illegible]
Between 11 and 20 years	12	[illegible]
Between 21 and 40 years	[illegible]	[illegible]
Between 41 and 60 years	[illegible]	19
Over 60 years	[illegible]	[illegible]

From this table it can be seen at a glance that children under ten years of age are most liable to acute intussusception, while the chronic form is more likely to attack the adult. From 598* cases in which both the age of the patient and the location of the intussusception were given, Leichtenstern constructed the following table:

Relation of the Age to the Situation of the Intussusception.

Age.	Total cases.	Ileo-cæcal.	Enteric.	Colic.	Ileo-colic.
		Per cent.	Per cent.	Per cent.	Per cent.
Under one year	153	[illegible]	6	19	[illegible]
2 to 5 years	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 to 10 years	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11 to 40 years	[illegible]	[illegible]	42	[illegible]	[illegible]
Over 40 years	[illegible]	[illegible]	42	[illegible]	[illegible]

We are at once struck by the fact that in children not over one year of age (who furnish, as we have seen, twenty-nine per cent. of the cases of intussusception), the ileo-cæcal variety occurs in nearly three-fourths of the cases, and the ileo-colic and enteric forms are very rare. Moreover, in children under eleven years, although the proportion of ileo-cæcal cases diminishes steadily up to that age, the percentage of colic cases remains very high, being from a fifth to a fourth of the whole number. Accordingly, the number of enteric intussusceptions does not greatly increase until the sixth year of life is reached. The well known fact that the mobility of the cæcum and the entire colon is so much greater in early childhood than later in life, readily explains the greater frequency of intussusceptions involving the large intestine at that period; for, as will soon be shown, mobility of the gut is a prerequisite of intussusception.

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* By an arithmetical error Leichtenstern's total in the table is made [illegible] in the original.

But little is known of the exciting causes of intussusception, the following table, altered from a similar one of Leichtenstern, showing all that can be extracted from the histories of reported cases upon this point. In a total of 587 cases, the history was sufficiently complete in 320 to allow conclusions to be drawn as to the cause.

Causes of Intussusception.

		Cases.	Per cent.
Taken suddenly ill while in good health		111	35
Mechanical causes (polypi [30 cases], cancer, stricture, undigested food, and foreign bodies)		64	20
Falls, blows upon the abdomen, violent exertion		26	8
Irregularities of the bowels, viz.:			
Diarrhœa	21	46	14
Dysentery	5		
Rectal gonorrhœa	4		
Colic from "taking cold"	6		
Constipation	4		
Simply "irregularities"	6		
Various complicating diseases (hernia, cholera, pregnancy, and childbed, etc.)		73	23
Total		320	

From these figures a third of the cases are seen to begin without warning, and without apparent cause, and probably this proportion is below what it should be, for some of the other assumed causes are far from being proven. According to many authors, including Treves, the disease appears to be more frequent in those who are in delicate health (anæmia, cardiac disease, phthisis), or convalescing from severe disease. But Leichtenstern expressly states that in his collected cases the contrary is the rule, for it more frequently attacked robust individuals. Rafinesque's small collection is about equally divided among the weakly and the strong. Many cases had some previous irregularity of the bowels, such as diarrhœa, dysentery,—and even constipation in a few instances. This agrees with what we shall presently see to be the result of experiments, that intussusception is most readily produced by spasmodic action of the intestinal muscle.

A few cases are reported to have been caused by "taking cold" by exposure, or by drinking cold water while heated, such being common causes of ordinary intestinal "colic." It has been a favorite supposition with writers upon this subject that all attacks of colic are intussusceptions, which reduce themselves spontaneously, or under the influence of narcotics. The name of Cruveilhier is especially associated with this idea. It is not at all likely that this theory can ever be proven, but it should be considered in the treatment of these attacks of colic, and it is a strong argument for the use of opiates, and the avoidance of purgatives in their treatment. In fact, the intussusception formed immediately after the giving of a purgative medicine (for intestinal worms, for instance), in two of Leichtenstern's cases. In this connection must be mentioned the fact that intussusceptions of the dying are said to be most common in children dying of meningitis and nervous affections, although no convincing evidence upon this point has yet been published.

A considerable number of cases have some definite mechanical cause, such as a polypus of the intestine, a narrowing of the canal by cancer or simple stricture, or the inversion of a Meckel's diverticulum. When a polypus is the exciting cause, it is generally small, attached opposite to the mesenteric border of the gut, and usually in the lower ileum (see Fig. 4905). But these polypi have been found as large as an egg or a pear, and they may occur in all parts of the intestine. The polypus generally forms the apex of the intussusceptum, although in some cases it has been attached to the bowel below. In the latter case it is probable that it has been only indirectly the cause of the invagination by exciting violent peristalsis; but, as a rule, the polypi act in a purely mechanical way by dragging upon the wall of the bowel at their point of attachment, and when they are urged on by the peristaltic movements, they turn it in at that point first, and then in the whole circumference. Whether Cruveilhier's case, elsewhere referred to, in which the polypus was attached to the middle layer of the intussusception, is to be interpreted as an accidental coincidence, or whether it is to be taken as proof of an unusual shifting of the layers of the intussusception after its formation, is uncertain, but probability inclines to the latter supposition. In a remarkable case reported by Homolle,[9] there were three intussusceptions, each caused by a polypus.

Becker[10] records a case in which an inverted Meckel's diverticulum, hanging into the lumen of the intestine, caused an intussusception by dragging upon the wall of the bowel in the same way as a polypus. A few similar cases are known to literature, and Treves describes a specimen in the Guy's Hospital museum, in London, which exhibits the same causation.

Masses of undigested food and foreign bodies are not infrequently the cause of intussusception, and appear to act by the increased peristalsis induced by the obstruction which they cause. Leichtenstern found twenty-eight cases of intussusception due to these foreign bodies, and Rafinesque found two such instances among his chronic cases. The foreign bodies in these cases have included, among others, apple-cores, pits of cherries or plums, beans, gall-stones, and portions of raw carrots. Treves describes a specimen in the museum of the University College, in London, in which an intussusception has formed, in the intestine of one of the lower animals, about a large piece of undigested tendon.

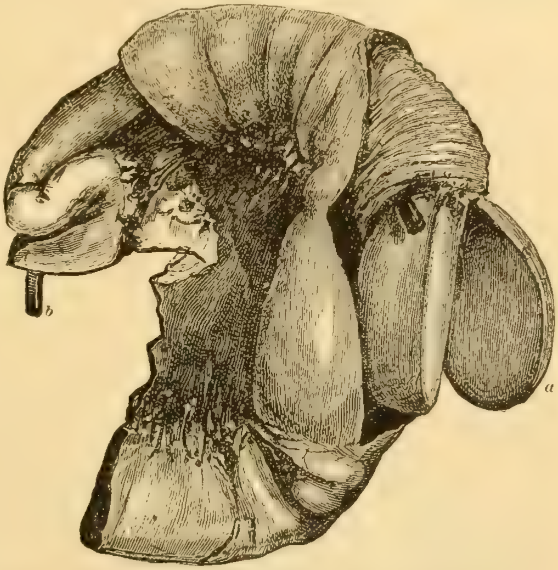

FIG. 4905.—Intussusception caused by a Polypus. (From Treves.) *a*, Polypus; *b*, bougie in the lumen of the gut.

In a certain number of cases the symptoms of intussusception have begun immediately after a blow upon the abdomen, a shock to the whole body received by falling from a height, or some unusual muscular exertion, and it is not difficult to believe that such traumatisms might cause irregular and spasmodic action of the intestinal muscles. In fact, it is easier to understand how such agents could cause an intussusception, than how they could produce some of the other forms of obstruction, in which such an injury not infrequently appears to be the cause.

MECHANISM.—There has always been much dispute as to the mechanism by which the intussusception is formed in the ordinary cases, in which there is no polypus or other evident mechanical cause. In ancient times it was regarded as the result of some sort of spasmodic action of the intestinal muscular coats, while later opinion favored the idea of a paralysis of these coats for a limited portion of the bowel. Leichtenstern is the most emphatic believer in the paralytic theory. There were three explanations possible under the theory of paralysis. The first of these supposed that the paralyzed part was drawn in by the part immediately below it—in fact, that it was swallowed by it, just as any body within the intestine would be passed on by the peristaltic movement. The second claimed that when the part immediately above the paralyzed loop was in contraction, the latter, offering no resistance, allowed the contracted part to force itself into the lumen of the paralyzed loop. The last and most plausible explanation was that the contracting part above propelled itself through the paralyzed loop into the part just beyond, inverting the paralyzed segment, and making it the middle layer of the intussusception. Leichtenstern and his followers overcame the objection that in a considerable number of cases there was colic, diarrhœa, dysentery, or some other derangement which would be more likely to be accompanied by spasm than by paralysis, with the supposition that in these cases paralysis came on as a natural consequence of the spasm, when the contractile power of the muscle was exhausted.

But, since Nothnagel's experiments upon peristalsis and intussusception, there can no longer be any doubt that the majority of intussusceptions, if not all, are the result of spasm. He opened the abdomen of etherized animals, most frequently rabbits, in a bath containing a half of one per cent. solution of salt, at the temperature of the blood, thus preserving the natural surroundings of the intestines as far as possible, and then applied faradic electricity to the bowel, and succeeded in producing intussusceptions at will. The writer has repeated these experiments and is able to verify Nothnagel's conclusions.

In some cases, when the abdomen was opened, active peristalsis was observed, especially in the duodenum, but as a rule the intestines lay quiet or waved gently to and fro in the "swinging" movements described by Van Braam Houckgeest, who first studied peristalsis with this method—movements which are supposed to be caused by contractions of the longitudinal fibres. In some cases the peristalsis was so violent as to produce spontaneous descending intussusception. In such cases a limited portion of the bowel was closely contracted, and the part next to it appeared to be drawn up over it, probably by the action of the longitudinal fibres. It might be mentioned here that Eichstädt (quoted by Leichtenstern) saw an intussusception form in a rabbit to which he had administered rhubarb, the contracting loop moving downward while the loop destined to form the sheath pushed itself from below upward over the first loop in an antiperistaltic direction. Therefore, this observer also saw a drawing up of the relaxed part, and not a moving down of the contracted. These spontaneous intussusceptions were always small, and reduced themselves generally at the end of ten minutes.

Having established the fact that mere mechanical irritation of the bowel by the electrode, without an electric current, produced only a local contraction, Nothnagel applied a faradic current to the intestine. The electrodes were held close together, so that the current passed only for a short distance through the intestinal wall. The writer employed a single electrode of the form designed by Ludwig for stimulation of the nerves, which passed the current in the long axis of the bowel for about a fourth of an inch. If the current is very weak only the part through which the current passes contracts.

As the strength of the current is increased, a contraction is seen to run upward toward the stomach for a couple of inches, and downward, for less than half that distance, being most intense beneath the electrodes, successive waves of contraction appearing to start from this point and to die out after reaching a certain length. The upper limit of this contraction is usually sharply marked, and occasionally a small ascending intussusception forms at that point, but this intussusception does not exceed a fourth of an inch in length, and soon reduces itself spontaneously, even before the contraction has entirely ceased. Even when there is active peristalsis just above it, the intussusception never grows larger. But this is not difficult to understand, for the direction of the invagination is opposed to that of the normal wave of peristalsis. The strong current produces more marked effects below the electrode. After an interval of some seconds, sometimes as much as two or three minutes, a descending intussusception appears at the end of the contracted portion of bowel below the electrodes. Sometimes an antiperistaltic wave seems to come up against this contracted part from below, and to force the relaxed portion over the contracted; but, as a rule, the relaxed part appears to be drawn over the contracted by the action of the longitudinal fibres, and this is probably the fact in every case, whatever the appearance may be. The receiving layer travels upward until it reaches the electrode, and then the growth ceases for a while. Then new contractions set in and the intestine below is seen to be drawn upward toward the electrode, where it turns in and disappears into the middle layer. Meanwhile the apex of the intussusception can be seen to be continually advancing downward, even for a distance of three or four inches. This advance of the apex evidently takes place by the constant turning in of fresh portions from the middle layer, to be added to the internal, for the external layer is firmly held by the electrode, and cannot move downward. This fact can be verified by watching the small vessels disappear in turn at the neck of the intussusception. Or two threads can be passed transversely under the serous coat of the gut a short distance apart and cut off short (see Fig. 2906). When the electrodes are applied at the upper thread, a, and the intussusception forms below it, the lower thread will be seen to pass up and disappear at the neck of the intussusception. If the latter is cut open longitudinally soon afterward, the lower thread will be found situated in the middle layer b, half-way between the neck and the apex.

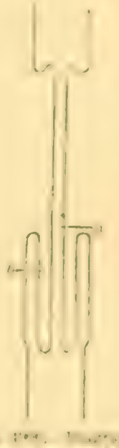

FIG. 2906.—Diagram Illustrating Intussusception Produced by Electricity. (From Nothnagel.)

If the electrodes are removed when the intussusception has been produced, the latter will remain quiescent for long periods, but exactly how long has not been ascertained, although Nothnagel saw the spontaneous intussusceptions mentioned above remain for ten minutes and then reduce themselves. He observed a large descending intussusception, which had been made under the electric stimulus, reduced by a downward movement of gas and fluid contents of the bowel in violent peristalsis. This would indicate that a purgative might cause the reduction of an intussusception, but clinical experience has shown that it is not safe to employ purgatives. He also observed an antiperistaltic wave, due to an enema of strong salt solution, reduce a spontaneous intussusception.

Nothnagel found that applying the electrodes directly to the intussusception produced an energetic contraction of its layers as a whole, and no reduction took place. Applying the electrodes below the intussusception, the ascending wave of contraction which spread over it gradually drew off the receiving layer and so reduced the intussusception. If the electrodes were reapplied above the intussusception, after having been removed, Nothnagel states that no result was obtained. The writer, however, found that such an application often reduced the intussusception, apparently by sending a wave of contraction through it which overcame the displacement, instead of causing all the layers to contract at once, as when the electrodes were applied directly to the intussusception itself. In fact, if the current was cut off and then suddenly reapplied, without removing the electrodes, the intussusception not infrequently reduced itself, and occasionally a sudden great increase in the strength of the current had the same effect. Sometimes, too, while the current was being tained without variations in strength, and even when the intussusception had reached a length of an inch or more, it would suddenly reduce itself, and then form again without any apparent reason. These unusual occurrences are probably to be explained by the variations in the waves of contraction running through the muscular fibres, for the contractions are never constant either in extent or in degree.

Nothnagel attempted to produce paralytic intussusceptions by crushing a portion of the bowel between forceps and then applying the electricity. When the electrodes were applied, just below the paralyzed loop, an intussusception formed below them, while the paralyzed part lay motionless above. When they were applied above the paralyzed portion, an anti-peristaltic wave swept upward as before, while below there was no contraction of any kind. The warm salt solution maintained the flexibility of the crushed loop, in spite of the extravasated blood, so that the presence of the latter could not account for the failure to produce an intussusception. Moreover, Nothnagel in one instance observed a spontaneous peristaltic wave come down upon the crushed loop, ceasing just above it, without producing an intussusception. This cessation was evidently due to the fact that the intestinal contents were arrested at the paralyzed part and distended the gut above, and that the contraction died out when it reached this distended portion. Active spontaneous peristalsis of the bowel, just below a paralyzed loop, also failed to produce an intussusception.

Leubuscher[11] made over a dozen experiments upon dogs by crushing a loop of the intestine until it was paralyzed, and then closing the abdomen, hoping to produce an intussusception. In only one case was an intussusception formed, and this was supposed by him to be an accidental coincidence, and not due to the paralysis.

The result of these experiments is to make the existence of a paralytic form of intussusception doubtful, while it is certain that intussusceptions are easily produced by spasm of the intestinal muscle, and may even occur spontaneously in consequence of strong contractions. Nothnagel's experiments make it probable, also, that the statement usually accepted heretofore, that a contracted part of the bowel was driven down into the part below, is incorrect. It appears to the eye as if the non-contracted portion were pulled up over the contracted, in the formation of the intussusception, and it seems reasonable to refer this movement to the longitudinal muscular coat. A good theoretical discussion of the mechanism of this movement has been made by Exner,[12] whose views are about as follows:

If the intestine is cut across, the edges of the wound are everted, owing to the contraction of the longitudinal muscular fibres which form the external layer of the intestinal cylinder, and, as they shorten, compel the internal layer to roll out. This action may frequently be observed to be preceded by a momentary inversion of the edges by a contraction of the circular fibres immediately at the edge of the wound. If we represent these actions in a diagrammatic section of the two layers of muscular fibres, as in Fig. 4907, A and B, *L* representing the longitudinal muscle, and *C* the circular, the longitudinal fibres contracting at the shaded part would produce an eversion of the intestinal wall as in A. B represents the circular fibres contracted in the shaded portion, with a consequent inversion of the wall of the bowel. The circular fibres could never produce eversion in a transverse wound of the bowel; consequently, when they alone contract in the normal bowel, no matter how sharply limited the contraction might be, the uncontracted portion of the gut would never be drawn over the contracted, and there would never be a tendency toward intussusception. The nearest possible approach to this displacement would be that shown in a section of the muscular layers of both walls of the intestine, as in C, in which the shaded part, *a b*, marks the limit of the contraction of the circular coat, and it is evident that an advance of the contraction toward *c* can do nothing more than reduce the calibre of the bowel at that point, as it did from *a* to *b*. But imagine that the longitudinal muscular fibres were also contracted, as in D, from *a′* to *b′*, a little in advance of *b*, bearing in mind the effect of such a contraction, as just shown in A. The curve *a′ b′* would at once become more concave, the curve *b c* remaining the same. If the circular coat at *b* be not very strongly contracted, it would be unable to oppose the longitudinal fibres and would be slightly everted. If the contracting wave should advance in the longitudinal coat, the curve *b c* would be constantly reversed, and a concave curve would be produced as at *a′ b′*, new portions of the intestinal wall being turned in all the time. If the contracting wave in the circular coat advanced at an equal rate of speed, but always keeping a little behind that in the longitudinal coat, the convex curve *a b* would constantly be reduced to the straight level of maximum contraction as at *a*. But if the contraction in the circular coat should at any moment outrun that in the longitudinal coat, so that it advanced from *b* to *c* before the latter had passed beyond *b′*, it will be seen (Fig. E) that an intussusception would at once begin to form, for the contracting circular fibres at *c* could not slip over the projecting curve *a b c*, and the intestinal wall would be sharply bent at that point, and would form the neck of the intussusception. When the intussusception had once formed, the further action of the longitudinal muscular fibres, even if its contraction should again run before that of the circular, would only tend to drag fresh portions of the intestinal wall around the convex curve *b′ c′*, and add them to the middle layer of the intussusception. If, however, the contraction wave in the circular fibres should continue in advance of that in the longitudinal, it would sweep around the curve beyond *c* to *d* as in F, and would fix that curve also. This would limit the extent

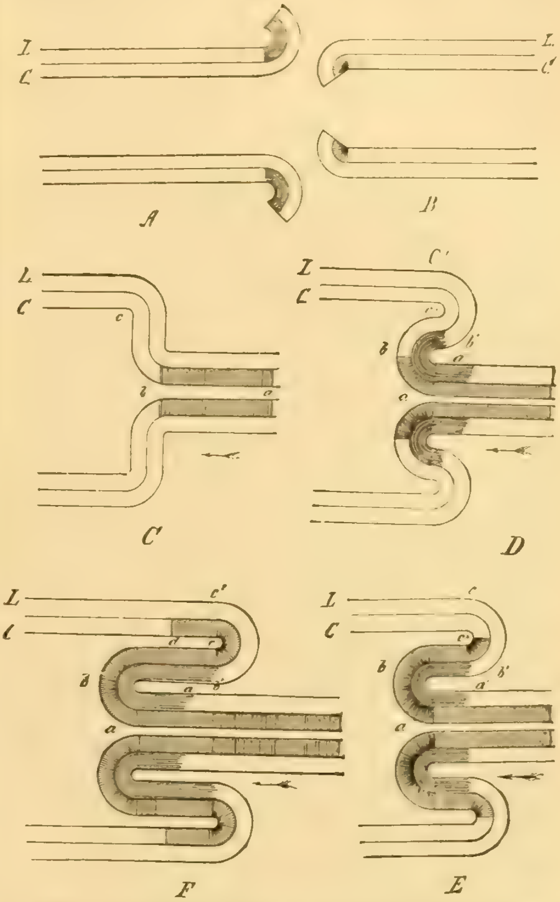

Fig. 4907.—Diagrams showing the Mode of Production of an Intussusception.

of the intussusceptum, unless the longitudinal fibres were strong enough to stretch the circular fibres at *d*, and to make the parts slip over one another, for the growth of the intussusception depends upon the constant advance of fresh portions of the wall of the bowel around the apex *b c*. But, practically, the increase of the intussusception is limited by the mass of included mesentery, and by the pathological changes which take place in the intestinal coats, and not by this contraction of the circular muscular coat.

A reversal of the above process would explain the mechanism of spontaneous reduction. In such a case the muscle in the included loop of bowel must be more or less relaxed, and then the advance of an antiperistaltic wave, in which the contraction of the longitudinal fibres predominates over that of the circular, would reduce the intussusception. For our theory it is unimportant whether the longitudinal fibres are in contraction or at rest when the contraction of the circular fibres be at its maximum, if we are allowed to suppose that the latter are the stronger of the two. But Ehrmann's experiments upon the innervation of the small intestine, "according with those of Fellner upon the rectum," indicate a crossed innervation of the two coats, the splanchnic nerve being the excitant nerve for the longitudinal fibres and inhibitory for the circular fibres, and the pneumogastric being the excitant nerve for the circular muscle and inhibitory for the longitudinal. If these results should be confirmed, both muscles would act to the greatest advantage, as in normal peristalsis the contraction of the two would not be simultaneous, and it would also give additional ground for our assumption that the contraction of the longitudinal fibres precedes that of the circular.

Some of Fellner's experiments just alluded to indicate that under certain circumstances a negative pressure, and consequent aspirating power, is developed in the rectum. Von Basch reasons from this that a similar aspirating mechanism might explain the occurrence of intussusception, the intussusceptum being actually sucked into the sheath. But this explanation is entirely theoretical and seems not a little fanciful.

Although Leichtenstern rejects the possibility of spasmodic intussusception in general, he claims that spasm of the ileo-cæcal valve is the cause of ileo-cæcal intussusceptions, comparing them with prolapse of the rectum, and Treves accepts this comparison. But even if we grant the existence of a strong sphincter muscle at the ileo-cæcal valve, there appears to be a very great difference between the two regions. On the one hand, we have a prolapse of the rectum through a sphincter attached to immovable structures, and with only the outer atmosphere beyond, the expulsive force of the abdominal muscles furnishing the motive power. On the other hand, in the supposed prolapse of the ileum into the cæcum the sphincter itself must, in the ileo-cæcal intussusceptions, be carried forward into a visceral cavity which is usually not immovably fixed—and in children, in whom this form of intussusception is most common, the cæcum is very freely movable. Besides being movable, the cæcum is folded up by the pressure of the viscera around it, or distended by gas or fæces. But, most important of all, there is no force driving the ileum into the cæcum, for the abdominal pressure is also acting upon the latter, whether collapsed or distended. The "peristaltic pressure" of which Leichtenstern speaks does not exist, for we have just seen that there is no propulsion of a contracted loop into a relaxed one in the production of intussusception. The only available force in this case is to be obtained by the contraction of the longitudinal muscular bands, and it seems quite reasonable to explain intussusception at this point by the same mechanism as elsewhere. The longitudinal muscular bands pass directly across from the ileum to the cæcum, and as the latter is so much the larger of the two, it ought theoretically to be much easier to produce an invagination here than elsewhere—certainly it would not demand such extreme circular contraction of the receiving layer. This explanation gains additional confirmation from the fact of the greater frequency of this form of intussusception in children, in whom the cæcum is often almost as freely movable as the small intestine. In the adult, however, the ileo-cæcal intussusceptions are not more frequent than those of the small intestine, for although the larger size of the cæcum renders intussusception liable to occur, the comparative fixity of its position in the adult would counterbalance this advantage.

The comparison of ileo-cæcal intussusception to prolapse of the rectum is also made by Leichtenstern, and is more exact, although he considers both as a result of tenesmus, whereas the cause should be sought in a relaxation of the sphincter muscle. Even in this case, however, the same theory serves to explain the mode of formation of the intussusception, and at the most we should have to depend upon the relative sufficiency of the valve to decide whether the intussusception in a given case would be ileo-cæcal or ileo-colic. If the valve were present the ileo-cæcal form would occur; if the valve were relaxed, the ileo-colic.

It can readily be shown by manipulation of the intestine in the cadaver that even moderate distention of the bowel by gas or fluid contents hinders the production of intussusception, and it is altogether doubtful whether a partial distention by either would favor it, although Leichtenstern claims the latter, clinging to his theory of prolapse.

Gay states that an adhesion of the intestine at any point, to the parietal surface of the abdomen, would increase the liability to intussusception, by giving a fixed point for the intestinal muscle to act upon. This theory was doubtless adduced to assist in the explanation of intussusception under the old idea that a contracted loop forced its way into a relaxed loop, and because the contracted portion of the intestine attains a certain rigidity it was imagined that if it was fixed at one end it could better thrust itself forward. From Nothnagel's experiments, however, we have learned that the apex of the intussusceptum is always directed away from the electrode, which may be considered a fixed point. The presence of the latter, indeed, seemed rather to hinder than to assist in the production of the intussusception, which would probably have formed with much greater ease if the entering layer could have been as free to move toward the receiving layer as the latter was to draw itself toward the former. The cases in which intussusception was associated with adhesions and upon which Gay's supposition was based, are far more easily explained as due to the increased peristalsis excited by the obstruction to the intestinal contents offered by the adhesions. Thus intussusceptions are frequently found associated with other forms of intestinal obstruction—tumors, internal incarceration in apertures, and volvulus—in all of which violent peristalsis must have been caused by the obstruction.

ANATOMY.—We have already seen that an intussusception is formed of three layers of the intestinal wall, and have explained their various names. Let us look a little more in detail at the structure of the intussusception tumor. We have already seen that the mesentery is dragged into the space between the internal and middle layers, forming a cone-shaped mass. The greatest thickness of the folded and wrinkled mesentery lies at the neck of the intussusception, and its pointed extremity is at the apex of the latter. Into this same interval a loop of intestine sometimes slips by the side of the mesentery, thus making one of the rare varieties of internal incarceration.

The mesentery in this new position has a very important influence upon the form of the tumor. When the mesentery is drawn into the intussusception there is more or less resistance, due to its increasing bulk and also to the traction upon its attachments, and this resistance produces a curving of the intussusception toward its attached border. The apex is consequently turned toward that side, and does not look directly forward into the lumen of the bowel, and the whole tumor is given a curved shape like a comma, or a curved link of sausage. The orifice at the apex of the intussusceptum also loses its originally circular form and becomes elongated into a slit, with its long diameter directed toward the mesenteric side. The intussusceptum is always more curved than the intussuscipiens. Treves claims that the axis of the former lies eccentrically nearer the mesenteric border than does that of the intussuscipiens. It is true that the axes of the two do not coincide, but as the mass of mesentery lies between the internal and middle layers it must certainly displace the axis of the intussusceptum away from the mesenteric border for the first part of its length, although, as has already been shown, the apex is directed toward that border. Probably Treves founded his statement upon the observation of specimens with inflammatory and œdematous changes, which are always most marked upon the free or convex border, and would cause a displacement of the axis of the intussusceptum toward the concave mesenteric border.

In the colon, intussusceptions are frequently straight, probably because the larger calibre of the bowel allows the mesocolon to enter with less traction.

The lumen of the bowel is not entirely obstructed at first, although it is diminished to a greater or less extent. This diminution is least in the ileo-cæcal intussusceptions, for here the sheath is formed by the colon, and there is much more space for the intussusception. The obliteration of the lumen is due to the changes which subsequently take place in the invaginated gut, but even in the chronic forms these changes may be absent, or very slight. In some cases the lumen of the intussusceptum admits the little finger when examined at the autopsy; in others it is almost entirely obliterated.

The direction of an intussusception may be either descending or ascending. The ascending intussusception, so called because the intussusceptum has its apex directed toward the stomach, thus ascending the stream of intestinal contents, would perhaps be better named *retrograde*, as suggested by Gay. Ascending intussusceptions are rare in the clinical forms, Leichtenstern having found only eight instances of primary ascending intussusceptions in his 593 cases, both the large and small intestine being represented in this group. But they are common in the intussusceptions which take place during the death-agony, and are not infrequently found associated with descending intussusceptions, probably owing to the disordered peristalsis caused by the obstruction to the intestinal contents, and they may lie below the obstruction (case of Power, "Path. Trans.," 1886, xxxvii., p. 240). These facts show that that there is no mechanical reason why the ascending intussusception does not occur as often as the descending, and the explanation of their infrequency must be sought elsewhere. Perhaps it is due to the fact that they are opposed to the direction of the normal peristaltic wave in the intestinal muscle; perhaps the continual downward pressure of the intestinal contents reduces them at once when they form. Both these circumstances may be altered in the death agony, for antiperistaltic movement appears to be not uncommon at that time, and the intestinal contents may not have time to reduce the intussusception before death takes place.

Besnier has reported a case of ascending intussusception which ran a chronic course. Senn,[16] in his experiments, produced an ascending intussusception two or three inches long in the colon of a cat, and it was found only partially reduced at the animal's death some days later. These facts show that in exceptional instances the ascending may have the same clinical history as the descending intussusceptions, and warrant us in using them to study the mechanical production of the displacement.

Lateral or *partial intussusception* has been described, being caused by the dimpling or drawing in of the wall of the bowel at the seat of attachment of a polypus, or by the inversion of a diverticulum. They are as rare as the so-called lateral hernias, but serve to show the mechanism of the beginning of intussusception from that cause.

In the *growth* of intussusceptions, when once formed, it is supposed that the peritoneal surfaces of the internal and middle layers remain stationary and do not glide upon each other, the intussusceptum moving as a whole into the sheath and the latter sliding upward over the middle layer, and being converted into it by turning in at the point of reflection. The mucous surfaces slip over each other with less friction than the serous. Thus fresh portions of the entering bowel are continually being covered in by fresh portions of the receiving bowel, and the apex of the intussusceptum is always constituted by the same portion of the gut. It is only in this way that growth is conceivable when adhesions have formed between the middle and internal layers. Cruveilhier, however, has recorded one instance in which a polypus was found attached to the middle layer, some distance behind the apex, and the supposition is that the polypus caused the intussusception, and that its attachment at first formed the apex of the intussusceptum in the usual way, but subsequently fresh portions of the internal layer slipped down and through the opening in the apex, these fresh portions then forming the apex, and the point of attachment of the polypus becoming part of the middle layer higher up. This is the only evidence extant for this mode of growth, and is not in itself sufficiently convincing to compel its admission. But the experiments of Nothnagel have shown that the different layers can slide upon each other, and render this supposition more tenable than was formerly thought. In these experiments the possibility of another mode of growth was clearly demonstrated, although the conditions were quite different from those which obtain in nature. This third method consisted in the constant turning in of a fresh portion of the external layer at the neck, so that it became the middle layer, and passed on until it reached the apex, where it was again turned upon itself and became transformed into the lowest part of the internal layer. In this mode of growth the other layers gained in length at the expense of the receiving bowel alone.

The *length* of an intussusception varies according to its position and variety. The rate of growth may be very rapid, especially in children, for the apex of an ileo-cæcal intussusception can be felt in the rectum a few hours after its first formation, as indicated by the symptoms. Leichtenstern found that in adults the enteric intussusceptions were the longest on the average, although the longest one in his cases was of the ileo-cæcal variety, the form which had always been supposed before his time to furnish the most extensive invaginations. In children the ileo-cæcal intussusceptions are the longest, being, according to Leichtenstern, longer in proportion than the same form in adults. The ileo-colic intussusceptions are the shortest, probably because of the very acute course and early strangulation common in them. It is self-evident that enteric invaginations in the lower ileum will be limited by the ileo-cæcal valve, and intussusceptions of the colon by the anus (although either of these may be forced and passed by the tumor), so that the possible length of an intussusception will depend in the first place upon its anatomical situation. It will also depend upon the movability of the portion of gut involved, for if the mesentery is long and at the same time thin, so as not to make too great bulk when invaginated, growth will be easy. But in the case of the large intestine it does not follow that the ascending colon must have a meso-colon long enough to reach up to the liver, across the abdomen to the splenic flexure, and then down upon the left side; for, although the invaginated bowel may take that course, the length of meso-colon required by the ascending colon in following it, will be indicated by a straight line from the situation of the ascending colon to the situation of the tumor at any given point of its progress, that progress following the circumference of a circle with the attached point of the meso-colon as a centre. A very important factor in determining the length which can be attained by an intussusception is the acuteness of the course, for in some varieties, and in some individuals, strangulation occurs so early that death takes place within a very few hours, or at most a few days.

Double and triple intussusceptions are sometimes found, the former being naturally not so rare as the latter, although seldom to occur. Like the ascending invaginations, they are frequently seen in the intussusceptions of the dying. The mechanism is the same as in the original formation of the intussusception. When the intussusception has been formed, the sheath becomes folded upon itself once or twice more, and thus an intussusception of five or even seven layers is produced (see Fig. 1889). More than seven layers has never been observed, and this perhaps indicates the extreme capacity of the gut as a sheath. Hodgson has reported a case of a triple intussusception, occurring in the jejunum measuring six inches in circumference. These cases are apt to have a chronic course, at least at first, and the secondary layers are not infrequently free from adhesions, showing that their formation is more recent than that of the original tumor. The mechanism of these forms is not definitely settled. The former supposition was that an ascending and a descending intussusception met and penetrated each other, and this explanation may be true of some cases. But it is rare to find these two forms within a short distance and with their apices directed toward each other.

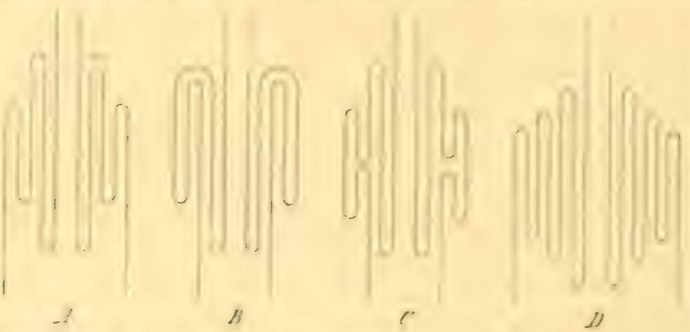

FIG. 1889.—A, B, C, Various forms of triple intussusception; D, quintuple intussusception.

An intussusception of five layers may be produced in another manner, and although this is not strictly a double intussusception, it affords a more probable explanation of their mechanism than that just alluded to. The five layers in this form are produced by the projection and secondary turning down of a transverse fold of the external layer of the intussusception outside of the original sheath, and this displacement is easily understood when it is noticed how marked is the transverse folding and wrinkling of the sheath in many instances. Treves quotes a case of this kind occurring in a child six months old dying with symptoms of intussusception. The autopsy revealed an intussusception of the colon in which the primary invagination was descending, five inches long, with adherent and congested layers. Outside of this was a double fold of sheath resembling a retrograde intussusception, formed in the manner just described, half the length of the primary tumor and without adhesions. Thus there were three layers of bowel at the upper end of the tumor, five in the middle, and three again at the lower end.

Multiple intussusceptions, that is, the simultaneous occurrence of two or more intussusceptions at once, are rare, except in those which take place in the death agony. In the latter variety, indeed, it is the rule to find several in one subject. When they do occur in the clinical form, there is usually one primary intussusception, to which the others are secondary, and not infrequently the latter are of the ascending variety. Sainz describes a very complicated case in which there was an ileocolic intussusception, and higher up also an intussusception of the ascending into the transverse colon. At the latter point a double intussusception had been produced, it is said, by the occurrence of an ascending intussusception which had passed outside and become fused with a descending one. But more probably this appearance was caused by the mechanism just described, a fold having been raised and folded over the original sheath.

PATHOLOGICAL CHANGES.—When an intussusception has existed for some time it undergoes certain changes in its various tissues, all of which owe their origin to the disturbance of circulation caused by the strangulation at the neck. This strangulation may be very slight, and in some cases there even seems to be no strangulation at all, and then the subsequent changes will be correspondingly slight, or they may be entirely absent. Among the chronic intussusceptions recorded by Rafinesque there are many cases in which there was no strangulation, and extraordinary as some of them appear, the evidence in their favor seems too strong to permit the rejection of even the cases of Léger, Brinton, and Fauquy. The first of these cases was in a woman sixty-five years of age who had been ill with vomiting, abdominal pain and tenderness, and constipation alternating with diarrhœa, for twelve months, but no tumor was ever discovered in the abdomen. The autopsy showed some old peritoneal adhesions, and an intussusception of the jejunum eighteen centimetres in length, but without any alterations in its tissues. Brinton's case occurred in a man who had been ill for six months, and the autopsy revealed an ileocæcal intussusception six inches long, in which a slight thickening of the coats of the intestine was the only pathological change. The last of these cases was also in a man who had been ill nearly a year, and after death a double intussusception of the jejunum was found, with only slight thickening of the intestine.

The very important question, from a clinical point of view, as to the time when adhesions take place, cannot be definitely answered. Extreme changes may take place in the tissues involved and yet no adhesions may form, as in the case reported by Lauer, in which a man, forty-three years of age, died after an illness of seventeen days, which had been supposed to be dysentery, and the post-mortem examination revealed a gangrenous intussusception in the sigmoid flexure, with rupture of the sheath and protrusion of the gangrenous intussusceptum, but without adhesions either at the neck or elsewhere. Quite as striking is the case in which Hutchinson found no adhesions or trace of peritonitis when he performed laparotomy and successfully reduced an ileocæcal intussusception in a girl, two years of age, in whom the symptoms had lasted for a month, and two inches of the cæcum had prolapsed from the anus for two weeks. If adhesions did not take place in an intussusception of a month's duration, subject to such violence as this must have received, it appears quite possible that they should be absent from cases of much longer duration, but not exposed to violence outside of the abdominal cavity. In fact, Hutchinson made the statement, in connection with this case, that adhesions are the exception in chronic intussusception. This is not a correct view, for it is certainly unusual for an intussusception to persist for any length of time without presenting at least some adhesions between the peritoneal surfaces. Rafinesque found in 23 cases of chronic intussusception, in which the point is noticed in the reports, that adhesions were present in 19, in 10 of which they were described as old and strong, while in only 4 cases were there no adhesions. The duration in these four cases was twenty days, three, ten, and thirteen months. In sixty cases of acute intussusception collected by Treves, there were adhesions in about forty-five per cent., but he thinks this figure below the reality.

In acute cases adhesions may be present, and even firm, in two or three days. Their formation depends chiefly upon the amount of strangulation in any case, for if the latter is slight there is nothing to excite even the slight peritonitis which gives rise to the exudation of lymph. The strangulation must at least be sufficient to obstruct the circulation in the implicated bowel. The adhesions may be confined to the neck of the intussusception, and this is the usual form, but occasionally they are limited to the apex, while the neck is free, and in such cases we may assume that the part of the intussusception where the adhesions are found was formed some time before the upper part, where there are no adhesions.

In rare cases they are seen in the form of bands at various points between the serous surfaces, or the serous surfaces are fused together throughout their entire extent. If there has been any inflammation or gangrene in the invaginated bowel, adhesions surround the whole tumor, and encapsulate it with the aid of surrounding coils of intestine, or other organs.

As we have already stated, the changes in the intussusception are the result of strangulation, and this primarily affects the intussusception alone, but the sheath is also altered secondarily by the great pressure exerted upon it by the swollen mass within. When the strangulation is limited in degree, the venous return of blood in the intussusceptum is interfered with in the first place, and venous congestion and œdema occur, with interstitial hæmorrhages into the tissues. All the tissues are affected in the same way, and the congestion of the peritoneal coat causes exudation of plastic material, and the formation of adhesions. The mucous membrane becomes œdematous, and if the strangulation is severe or long continued, ulceration takes place. A few rare cases have been reported in which the internal and middle layers have become fused, in consequence of this ulceration, by the union of the raw surfaces which have been produced. Meantime the muscular coats and cellular tissue of the intestinal wall have swollen, and if a moderate degree of constriction has existed for a long time without being so intense as to produce gangrene, these tissues become enormously hypertrophied. Probably this hypertrophy does not affect the muscular coat, although it is true that Lettsom[23] mentions a case in which there appeared to be a true hypertrophy of the muscular layer, even allowing for the fact that an intense degree of contraction would naturally result in a thickening of the walls of any hollow muscular viscus. Cruveilhier also[24] found an increase of muscular tissue.

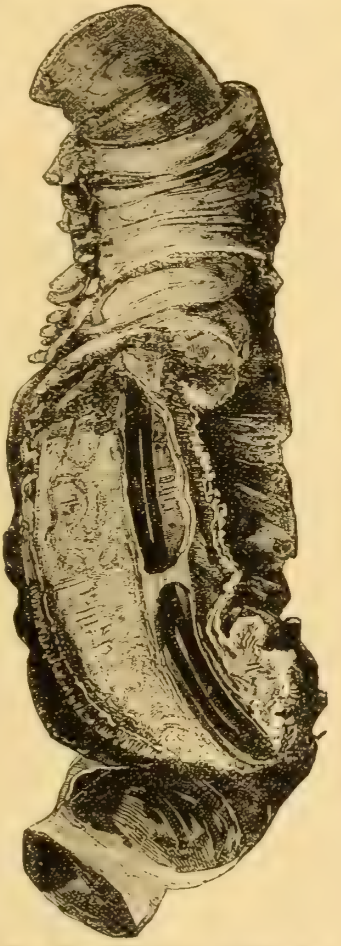

FIG. 4909.—Epithelioma growing in a Chronic Intussusception. (From Treves.) A bougie indicates the lumen of the intussusceptum.

The increase in the thickness of the intestinal wall is most marked in the middle layer, and the sheath is but very seldom affected. The wall of the middle layer has been found as thick as a third, or even half an inch, and the two layers of the intussusceptum have been found to measure seventeen millimetres. In one case the thickness of all three layers together is given as one inch. The swelling and increase in thickness is naturally greatest at the apex and on the convex side of the tumor, for here there is the least resistance. On the concave side the pressure caused by the folding due to the traction of the mesentery is very great, and it is increased by the crowding in of the mesentery itself at that point. This eccentric hypertrophy of the layers results in a displacement of the axis of the intussusceptum toward the mesenteric border. Treves describes a remarkable specimen in which an annular epithelioma appeared to have been the cause of the intussusception, which ran a chronic course for twelve months before death, when it was found that the later growth of the epithelioma had followed the law just stated in regard to œdema and hypertrophy, and had chiefly extended upon the convex side of the intussusceptum (Fig. 4909).

On the other hand, the great pressure to which the internal layers are subjected may cause atrophy, as in a case of acute intussusception in a child thirteen years of age,[25] in which the internal layer was reduced to the size of the iliac artery. It has even been claimed that recovery could take place in this way by a complete atrophy and disappearance of the intussusceptum, with a return of the bowel to its normal calibre; but, as Leichtenstern points out, it is much easier to explain these cases by assuming them to have been examples of a molecular gangrene of the intussusceptum, in which it passed away in such small pieces that no traces of the slough were discovered in the stools.

Close upon the heels of the congestion, œdema, and interstitial hæmorrhages comes the fatal change of gangrene. But the time of its appearance is very variable, being entirely dependent upon the amount of strangulation in the tumor. Judson[26] has reported a case in which gangrene was found twelve hours after the beginning of the symptoms. If strangulation is absent, there can be no gangrene. If it is slight, gangrene is long delayed, and it may be entirely absent in this case also, especially in intussusceptions with a chronic course. But even if the strangulation remains for a long time very slight in a chronic intussusception, it may develop very suddenly later, and terminate life even more quickly than in the ordinary acute cases, for the patient is already weakened by the long-continued ailment. If the strangulation is severe from the first, early gangrene is inevitable, unless death should ensue before it has time to develop fully, being caused by the severe nervous shock due to the strangulation.

Gangrene may attack various parts of the intussusception. Usually in this, as in other alterations to which the tumor is subject, it is the middle layer which suffers earliest and most frequently, and the sheath is generally exempt. Thus in Rafinesque's fifty-five cases the sheath was perforated in eight cases, friable or nearly gangrenous in three others, and probably healthy in the rest. In every case in which perforation of the sheath had taken place, the inner and middle layers were also gangrenous. When the sheath becomes gangrenous, the intussusceptum very frequently projects through the opening into the peritoneal cavity (see Fig. 4910), and in one case, reported by Reydellet,[27] the sigmoid flexure was found entirely divided "by suppuration," and the apex of a strangulated intussusception of the colon projected from the upper end. Sometimes the perforation consists of a small opening involving the sheath alone.

Although strangulation is much more common in acute cases than in chronic, gangrene is not. Leichtenstern found perforation at the affected loop, or above it, in sixteen per cent. of 175 cases, including both acute and chronic, while Rafinesque found it in twenty-two per cent. in 55 cases of chronic intussusception.

It is owing to this common exemption of the sheath from destructive changes, and the comparative rarity of perforation, that spontaneous cure of an intussusception is possible without reduction of the invaginated bowel. A considerable number of instances of spontaneous cure by elimination of the sloughing intussusceptum are known. Leichtenstern found 125 instances of this elimination of the invaginated gut in his series of 593 cases; but Rafinesque found only 6 in his 55 cases of chronic intussusception. It will generally be shown that the process of sloughing is dangerous, and only a small proportion of these cases made an ultimate recovery.

Occasionally the elimination is gradual, the gangrene beginning at the apex of the intussusception and extending gradually toward the neck; but this is an unusual process, and not likely to occur except in chronic cases. Generally the sloughing begins at the neck, just as in the case of a tumor surrounded by a ligature, and the intussusceptum is thrown off in a mass. As the changes are generally most advanced in the middle layer this layer may be unrecognizable in the fragments of eliminated bowel, while the internal layer appears tolerably well preserved. If peritoneal adhesions have formed, the two layers are passed from the anus in the same position that they occupied in the intussusception. But if there are no adhesions between their serous surfaces, as separation is generally first completed in one layer, the other holding a while longer, the invaginated gut becomes unfolded, and is passed in a long continuous piece. Usually the middle layer gives way first, and, as will be seen by Fig. 2911, B, it slips down over the internal layer, turning its mucous surface inward to its natural position, so that the whole length of bowel hangs down in the lumen of the intestine below, dependent from the neck of the internal layer; and when this finally gives way the slough passes off with the mucous surface internal and the serous surface external. But if the reverse should occur, and the internal layer should first separate at the neck, the internal layer would slip down inside of the middle (Fig. 2911, C), and turn inside out to correspond with the latter, its mucous surface becoming external, so that when passed the strip of bowel would be found turned inside out in its entire length.

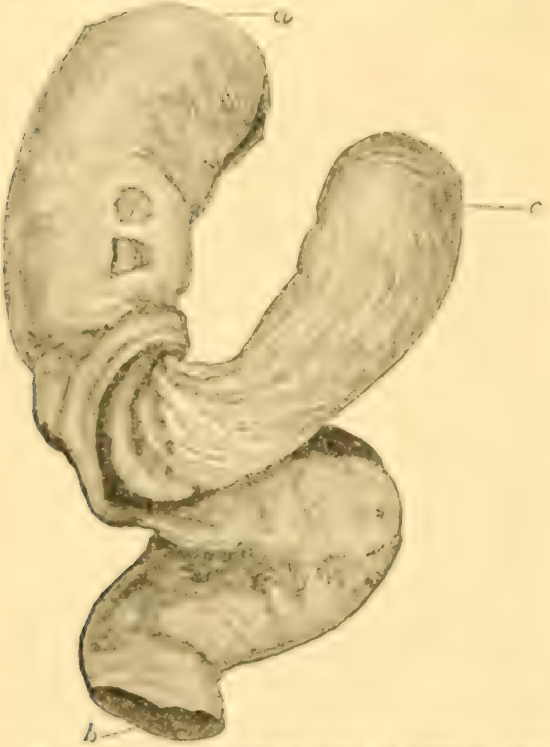

Fig. 2910.—Intussusception protruding through a gangrenous sheath. (From Treves.) a, [illegible]; b, [illegible]; c, [illegible].

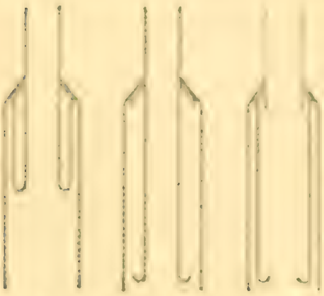

Fig. 2911.—Diagrammatic section of an Intussusception with adhesions. B, separation of middle layer; C, separation of internal layer.

The length of intestine thus thrown off varies from a few inches to several feet. It usually includes the whole length of the intussusception, but the recorded cases where several separate pieces are said to have been passed are more easily understood by supposing repeated progressive invaginations of the gut at the same point, with elimination of each in turn, than to imagine that several lines of demarcation would be formed in the intussusceptum. Such a case is recorded by [illegible] in which eight pieces of gut were rejected in three years, making a total length of twelve feet, with final recovery; the history being verified by an autopsy two years later showing slight stricture of the gut at the point where the ileum joined the colon.

A very few cases have been observed in which the gangrene attacked a limited part of one side of the intussusceptum, including both layers, and an opening was thus established between the lumen of the bowel above the apex and that below, without opening the general peritoneal cavity. Temporary recovery was the result. This termination would not be possible except in cases with a chronic course.

From what has preceded it is evident that intestinal obstruction, irreducibility of the intussusception, and strangulation of the latter, are not all equivalent terms, nor are they all present in every case of intussusception. We have already seen that in the majority of cases the lumen of the gut is not entirely obstructed, and this is also shown by the alternation of constipation and diarrhoea. In fact, the passage is sometimes large enough to admit the little finger. But fæcal obstruction may occur when the lumen of the bowel is not entirely closed, and it may even result simply from paralysis of the muscular coats of the bowel without any mechanical obstruction. In one curious case reported, laparotomy was performed after symptoms of intestinal obstruction had existed for some months, and the only cause found was a reduction of the calibre of the bowel, for a space of some inches, to the diameter of the little finger, by an "inflammatory stricture." The functional obstruction so often observed in peritonitis is an example of what may result from simple paralysis of the intestinal muscle. On the other hand, a very small opening in the lumen of the bowel will sometimes transmit the intestinal contents so readily as to give no symptoms for a long time, until some hard body becomes engaged in the opening and causes total obstruction and death, with the most acute symptoms. Thus Stimson has reported a case of acute intestinal obstruction resulting fatally, in which autopsy revealed an annular cancer of the large intestine which had never been suspected, although the opening through it was so small that an apple-seed had blocked it and caused death. Probably the length of the strictured part bears some relation to the amount of obstruction, a long comparatively slight stricture being the equivalent of a narrow stricture involving only a short length of the bowel. The amount of intestinal obstruction caused by an intussusception will depend, then, upon the calibre of the canal through the affected loop of bowel and the length of implicated intestine; upon the power of the intestinal muscle to overcome the increased resistance to the passage of the fæces; and upon the freedom of the latter from hard objects of a size sufficient to block the passage. The experiments of Nothnagel have demonstrated that complete intestinal obstruction by intussusception, or by any other cause, does not in itself produce antiperistalsis as it was supposed to do, by reflex nervous action; consequently we cannot look to this for an explanation of the obstructive symptoms in these cases. In the early stages of an intussusception there is no serious obstruction, but it may develop later in consequence of the changes in the parts caused by strangulation or by surrounding inflammation. Thus Senn found in two experimental intussusceptions, made in the intestine of cats, that bending and fixation of the gut by surrounding peritonitis had caused the complete obstruction which resulted in the death of the animals.

The irreducibility of an intussusception also depends upon several factors, but all of these factors depend in turn upon the degree of obstruction to the circulation of the blood. The commonest cause for the irreducibility of an intussusception is its increase in bulk by œdema in acute cases, and by œdema and hypertrophy in chronic cases. The formation of adhesions is also, probably, in most cases due to the stagnation of the blood. It would be supposed that adhesions must form at once if there were any gangrene of the bowel, but we have already quoted a case which proves that they may be absent even when the strangulation is so intense as to cause gangrene —in fact, the very intensity of the process explains why adhesions are not formed in some cases, death of the tissues taking place before the lymph necessary for the formation of adhesions can be thrown out. Thus, if the strangulation simply causes congestion, or if it gives rise to inflammatory processes by partial gangrene, adhesions are formed. But if it result in the immediate death of the tissues in the intussusceptum, there may be no adhesions. We must also recollect that the impeded circulation in the intestinal wall, due to the strangulation, will allow micro-organisms to penetrate to the peritoneal coat, and either adhesive or purulent peritonitis may be caused without any actual gangrene or perforation.

We cannot divide the course of an intussusception into reducibility, irreducibility, and strangulation; for all intussusceptions which are strangulated are not irreducible, and some may even be reduced with a certain degree of ease. In many chronic intussusceptions the adhesions have grown so strong as to render reduction impossible, and yet their long course and the slight alterations found in the walls of the implicated bowel show that they are not strangulated, in the clinical sense of the term, although there is an obstruction to the circulation of the blood. In such cases an acute strangulation may suddenly cause the death of the patient, after he has borne his intussusception for some time without severe symptoms.

Strangulation may or may not be present in any case; it may be present later on when not found at first, and it may occur in every grade of intensity. It is most frequent in the acute cases, and is generally due simply to the mechanical pressure of the mesentery, where it passes through the neck of the intussusception. At a later stage it may be caused by the pressure of the intestinal contents above the intussusception, when their passage has been obstructed in some way in the progress of a chronic or subacute case. Once having been set up by any cause, the strangulation continues, unless the swelling of the tissues at the neck of the intussusception is relieved by hemorrhage from the intussusceptum, when spontaneous reduction becomes possible. We have already seen that the various grades of changes in the tissues correspond to the varying intensity of the strangulation. To appreciate these differences, it is only necessary to recall the resemblance between hernia and intussusception, which has been insisted upon by so many writers upon the subject. In hernia we have the reducible, irreducible, and strangulated forms—that is, forms without any change and easily replaced, forms with changes which render them irreducible, but which are not incompatible with the life of the parts; and finally, forms in which death of the parts must surely follow. We might even carry the comparison further, and associate the spontaneous cure of strangulated hernia by the formation of an external fæcal fistula, with the spontaneous cure of intussusception by sloughing. But it must be borne in mind that the similarity is not exact in all respects, and mainly because of the difference in the use of the word reducible. Applied to hernia, this means only reducibility by the taxis; but applied to intussusceptions, it includes those reducible spontaneously, by such means as enemata, and also by direct manipulation and traction upon the gut with the fingers after the abdomen has been opened. In the latter sense of the term it will be acknowledged that many strangulated herniæ would prove reducible, even without enlarging the neck of the sac.

Symptoms and Course.—In order to understand the proper value of the various symptoms in intussusception we must first divide it into its different clinical forms, as indicated by the course of the disease. There are four different types—the peracute, acute, subacute, and chronic. While in the main it is easy to separate all cases into these four classes, some artificial distinctions must be made, and the principal of these is the limitation of the chronic cases to all those which run for a month or more.

1. The peracute cases are those in which death occurs very early, often in a few hours, and in which death is probably due to the shock caused by the strangulation of the gut. These cases are very rare, for in Leichtenstern's two hundred and sixty-nine fatal cases, in which the time of death was given, there are only five which perished in the first twenty-four hours.

2. The acute cases represent the great majority, nearly one-half of all the fatal cases, and yet in intussusception their proportion is less than in many other forms of intestinal obstruction.

3. The subacute cases are those in which the duration of the disease is more than a week, but less than a month; and this is the most artificial of all the classes. Nevertheless it includes a large number of cases, and a larger number than the thirty-one per cent. assigned to it in the following table; for that proportion is calculated only upon the fatal cases, whereas nearly all the cases of intussusception which recover are of the subacute variety. From a clinical stand-point the cases included in this class are of two sorts—first, those acute cases in which, in spite of the very violent symptoms, the powers of resistance of the patient are so great as to postpone the end beyond the usual term of seven days; and secondly, the cases which are much milder in their symptoms, and present a true subacute course.

4. Finally, there are the chronic cases, which last longer than a month. Here, also, there are two varieties of cases—the true chronic cases with very mild symptoms from the first, or, at least, after the first two or three days; and subacute cases, which are prolonged into the second month simply by the endurance of the patient.

From one of Leichtenstern's tables we deduce the following figures, showing the relative frequency of the different forms in the fatal cases:

Relative Frequency of the Clinical Varieties.

Variety.	Time of death.	Total cases.	Percentage.
Peracute	First day.	5	1.8
Acute	2 to 7 days.	129	47.9
Subacute	7 to 30 days.	84	31.2
Chronic	Over 30 days.	51	18.9

The course which the disease will run cannot be predicted from the mode of its onset, for the latter may be very violent, and yet, after a few hours or days, the first symptoms may subside, and the disease may assume a chronic type, lasting for months or even years. Conversely, a case may begin as a chronic intussusception, and yet the symptoms of acute internal strangulation may set in suddenly at any time, and terminate the life of the patient in a few hours. Chronic cases frequently have more or less acute exacerbations.

The order of the appearance of the symptoms may also vary. Thus, while pain is usually the first sign of the disease, in other cases an alternation of diarrhœa and constipation, tenesmus of the rectum and anus, or even the discovery of a tumor in the abdomen, may give the first indication.

As a rule, however, the attack begins with a sudden and very violent pain in the abdomen, usually without any previous injury or illness, even in the midst of sleep, lasting for some time, and then diminishing or even passing away altogether. After a varying interval it returns, sometimes with increased vigor. There may be vomiting, but this is often absent. Some of the signs of internal strangulation, such as shock, and diminution of the urine, are frequently present. In the intervals, and also during the paroxysms, some tenderness of the abdomen will be noticed, and this will increase as the case progresses. After a time a sausage-shaped tumor will be found in the abdomen. There will be frequent small passages of blood and mucus. The attacks of pain come more and more frequently, vomiting may set in with complete intestinal obstruction. The patient finally dies of exhaustion, or of peritonitis caused by perforation of the gut. Let us now study each symptom in detail.

Shock, Collapse.—In the peracute cases the onset of the disease may be so violent that very great shock is caused by the strangulation of the parts. But we have seen that these cases are very rare, and in Leichtenstern's five cases four occurred in children under one year of age. As a rule, there is little shock in the ordinary cases, and the general condition of the patient remains good until his sufferings and want of food produce exhaustion, which generally sets in from the third to the seventh day; but in subacute cases it may be delayed until the third week, and in chronic cases even for months. When shock is present it gives the usual picture of pallor, relaxation, cold sweating, superficial respiration, feeble pulse, subnormal temperature, and diminished urine.

Temperature.—In acute strangulation from bands, a subnormal temperature is the rule. But even in uncomplicated cases of intussusception the temperature is usually slightly above normal, 99° to 100° F., although it may sink below if the shock is pronounced. Fever is more marked in the later stages of the disease, when peritonitis has begun or some other complication is developing. But as septic peritonitis not infrequently runs its course without fever, there may be no decided elevation of temperature throughout the disease, even in these cases, except perhaps just before death. A rise of temperature, however, does not necessarily imply the presence of peritonitis, especially as so many cases of intussusception occur in children, in whom the liability to fever from slight causes is so well known. Thus, [illegible] has reported a case in a girl, eleven years of age, in which the temperature was over 101° F. on the seventh and eighth days. Forced enemata reduced the intussusception, and on the next day the temperature dropped to normal.

Urine.—If shock is present the urine may be diminished in quantity; but, as a rule, there will be no perceptible change. The theory that the diminution of urine is much greater when the lesion is situated very high up in the intestinal tract is not supported by facts. It has, on the contrary, been proven that diminution of the urine is as likely to occur in intussusception at a distance from the stomach as when it is close to the pylorus, allowance being made for the relative severity of the symptoms in each case; for the amount of the urine depends more upon the severity of the symptoms than upon any other one factor. In chronic cases of some days' duration it may well be that (as Barlow and Leichtenstern claim) the considerable loss of fluids by diarrhœa, and the difficult introduction of fluids on account of vomiting, may reduce the quantity of the urine, just as in stenosis of the pylorus. But it is difficult to believe that this effect would make itself noticeable in the acute form of the disease, and whenever the urine is diminished in such cases it must be referred to the shock, which might diminish the urine either by the reduction of the blood pressure, or by the reflex nervous action of the strangulation, as is so frequently seen in hernia and abdominal injury. Leichtenstern expressly says that shock was present in all his cases in which the urine was lessened in quantity.

Physical Examination. Attitude.—During the paroxysms of pain the patient will be seen to twist himself into various positions, but generally with trunk and limbs flexed to relax the abdominal muscles. Sometimes he will discover that the pain is lessened by lying always upon one side; sometimes pressure upon the abdomen will relieve the pain. In a few cases the position of opisthotonos has been assumed, and this has not only been observed in young children, in whom it might be taken to be the result of convulsive nervous action, but in the case of adults, who assumed it voluntarily because the pain seemed to be less in that position. Between the paroxysms the attitude may be natural and entirely unconstrained, but, even before any abdominal tenderness has developed, a more or less flexed position is often maintained; and in chronic cases the patient often walks about bent forward in a very characteristic attitude. But all these positions of the body only indicate the fact that an abdominal lesion of some kind is present. So, also, the anxious, haggard look of the face is simply indicative of pain and exhaustion, and the later emaciation merely shows the lack of rest and nutrition.

Appearance of the Abdomen.—The abdomen is generally flat, but it is sometimes slightly distended. Occasionally the muscles are rigid and retracted, but as a rule they are soft. The percussion sounds are usually normal, although there is sometimes a slight dulness over the tumor, especially if it be of large size. Dance described a depression in the right iliac region, when compared with that of the other side, as pathognomonic of intussusception with displacement of the cæcum. But this appearance is rarely seen, and chiefly when the intussusception has reached the left side, so that the fulness of that region makes more evident the depression upon the right. Leichtenstern remarks, however, upon the value of the artificial production of the "sign of Dance" by the injection of large quantities of water or air, which distend the colon upon the left side of the abdomen below the intussusception, while the other side remains flat. When peritonitis begins all the conditions are altered, and tympanites develops; but owing to the rarity of complete obstruction of the bowel in intussusception, the distention is seldom so extreme as in other forms of intestinal obstruction. The patient is generally so exhausted by the time that peritonitis sets in, that death terminates the scene before tympanites can fully develop. If perforation of the bowel should occur very suddenly, before adhesions had time to form, tympanites might appear at once, with loss of liver dulness. On the other hand, in some cases of septic peritonitis, tympanites and abdominal tenderness are absent throughout, and the disease runs a concealed course, presenting only the symptoms of sepsis.

Tumor.—But the most important of all the points to be ascertained by physical examination is the presence of a tumor in the abdomen, and its peculiar characteristics. If the typical form of tumor can be found, it is sufficiently pathognomonic to base a diagnosis upon, even without the aid of other symptoms. Leichtenstern in four hundred and thirty-three cases of all kinds, and Rafinesque in fifty-three cases of chronic intussusception, found that a tumor was present in about fifty per cent. of the cases. It is probable that, as Rafinesque observes, a more careful examination of the patients would have resulted in the discovery of the tumor in many more, especially with the aid of an anæsthetic. The frequency of a recognizable tumor varies a little with the different kinds of intussusception, and its position is also somewhat dependent upon the seat of the lesion. According to Leichtenstern, the figures as to frequency are as follows:

In [illegible] cases of [illegible] intussusception a tumor was found in [illegible] per ct.
" [illegible] " " [illegible] " " [illegible] "
" [illegible] " " [illegible] " " [illegible] "
" [illegible] " " [illegible] " " [illegible] "

This table shows that the tumor is more often found when the intussusception involves the large intestine, as is natural, because of its larger size in this situation, and because it can be reached by a rectal examination. On the other hand, the tumors of intussusception of the small intestine are small, and often lie in regions which are not accessible to exploration.

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* According to [illegible] and R[illegible] [illegible].

Contrary to the statement of Rilliet, the tumor is more often recognized in children than in adults, because tympanites is of less frequent occurrence in children, and because of the great frequency of intussusceptions involving the large intestine in them. According to Leichtenstern, the tumor was found in sixty-three per cent. of the cases occurring during the first year of life, against fifty per cent. in adults.

In Leichtenstern's cases the tumor was found upon the right side of the abdomen 34 times, upon the left side and in the rectum 144 times, and in the region of the transverse colon only 19 times. In the children it was almost without exception found upon the left side. The reason for this frequent location of the tumor upon the left side is to be sought in the tendency of a tumor to move onward, so that an ileo-cæcal intussusception, for example, could only be found upon the right side during the first few hours or days. Moreover, when an ileo-cæcal tumor first forms it is small, and often too soft to be recognized, and while passing through the transverse colon in the second part of its course it would be concealed behind the ribs; consequently it would be most easily felt when it had reached the descending colon in the left side, and by that time its consistency would also have increased. It is true that Leichtenstern expressly states that in his cases the tumor was generally discovered very soon after the first onset of the symptoms, but this is not inconsistent with the explanation just given, for the growth of the tumor is often very rapid. Instances of very slow growth are also referred to by Leichtenstern. In eight cases a tumor of the transverse colon was observed to pass on into the sigmoid flexure, and twice the cæcum was followed as it passed through the transverse colon to the same position.

The tumors formed by intussusception of the small intestine were found in Leichtenstern's cases nine times in the region of the cæcum, seven times in the epigastric and hypochondriac regions, three times each in the left iliac and hypogastric regions. These figures show that no conclusions can be drawn from the seat of the tumor to aid in the diagnosis of the location of the intussusception.

In the 222 cases of Leichtenstern's collection in which a tumor was noted, it could be felt by rectal examination in 31, and it prolapsed from the anus in 41—giving a total of 72 cases. Of course none of these intussusceptions were in the small intestine, but 30 were ileo-cæcal, and 2 were ileo-colic. The tumor makes its appearance in the rectum in children much more quickly than in adults, having been observed in children as early as the second day; but exceptionally it has also been found in adults at an early period. The tumor has generally been discovered in the rectum about the seventh day, except in the chronic cases, in which its average appearance in that situation takes place on the fifteenth day. But in some chronic cases it may not reach the rectum until the sixth or seventh month. Some cases have been recorded in which the tumor prolapsed through the anus at the very beginning of the symptoms of intussusception, but in these the lesion involved only the lowest part of the colon.

The tumor, when felt through the abdominal walls, is sausage-shaped, and is generally curved. Its consistency varies with the amount of constriction and œdema, and also with the degree of contraction of the muscle in the involved bowel. Owing to the latter fact the consistency may vary at different times, even becoming so soft that the tumor is no longer recognizable to the touch. The tumor has, indeed, been observed to grow hard, or undergo a sort of erection under the examining hand. The hardening of the tumor is accompanied with pain, from the spasmodic contraction of the muscular coats, and therefore the search for it should not be concluded until an examination has been made during the paroxysm, for the soft tumor between the paroxysms may be overlooked. The tumor itself is not usually tender to pressure, unless the disease has lasted for some time. The position of the mass is generally more or less fixed, but it is sometimes movable under the hand, and it may sometimes be made to change its place by enemata. As it drags upon the mesentery in its formation, it is more fixed as regards motion downward than in other directions, as is the case with neoplasms of the mesentery itself. The tumor has been observed to move spontaneously under the influence of peristalsis, and, as we have seen, it can sometimes be followed during the progress of the case in its advance toward the anus.

The length of the tumor is seldom great, and very rarely over six inches, even with the largest invaginations, for they are shortened by the wrinkling of their coats, and they are often concealed under the ribs in part of their length. Sometimes two tumors can be felt, and one of these will generally prove to be gas or intestinal contents held back by the obstruction in the lumen of the bowel. In other cases the two will prove to be only the two ends of one tumor, the intervening part lying behind the ribs. But a few cases of multiple intussusceptions have been reported in which two or three distinct tumors were felt during life.

Pain.—One of the principal symptoms of intussusception, and a very constant one, is pain. It is generally the first symptom, and is very characteristic. The solitary case referred to by Leichtenstern in which no pain was present is incorrectly quoted, for it was a case of obstruction due to a band, and not to intussusception, and pain was present at the beginning. As a rule, in cases of intussusception the pain comes without warning, even in the midst of sleep. But sometimes it may be preceded by diarrhœa, slight attacks of colic, or uneasy feelings in the abdomen. Or it may follow more or less immediately upon some overexertion or abdominal injury. The character of the pain is paroxysmal, similar to that of ordinary colic, and is generally described as twisting, pinching, tearing, or burning. In some cases it may be relieved by pressure upon the abdomen, and especially over the seat of the tumor. The intensity of the pain is very great when at its worst, and it is often described as agonizing, but according to Treves it is generally less severe than the pain of other forms of acute intestinal obstruction. In children the pain is often so intense as to bring on convulsions.

The paroxysm may reach its greatest intensity at once, but usually it is not quite so violent at the beginning, gradually increases in severity, and then as gradually diminishes. In some cases, however, the pain terminates as suddenly as it began. The first paroxysm may be the worst of all; but, as a rule, the severity of the pain increases with each succeeding attack, and the intervals between the paroxysms grow shorter and shorter as the case progresses, up to a certain point, when a distinct abatement of the sufferings of the patient takes place. This remission is supposed to coincide with the final fixation of the loop of gut by adhesions, or by constriction; but, whatever its cause, it is a characteristic feature of intussusception. There are usually several attacks of pain in the twenty-four hours, and sometimes they are more frequent in the night than in the daytime.

The intervals are of varying length, but sometimes a marked periodicity may be observed in the occurrence of the paroxysms, which come at regular intervals and last for a certain length of time. The pain is said by some to be most intense, and the intervals shortest, when the intussusception is situated in the small intestine; but others claim that the ileo-colic form is the worst in this respect. In chronic cases the pain is generally less severe and the intervals are longer, but the pain is paroxysmal and similar in character to that in the acute cases. During the intervals the patient may be entirely free from pain, and this is especially common in children; but generally there is some pain between the paroxysms, and in some cases even from the very onset of the disease the pain is continuous, with periodic exacerbations. A feeling of soreness or tenderness in the abdomen may be present in the intervals, and later in the case may cause as much discomfort as the paroxysm of pain itself, even before there is any extensive peritonitis.

The pain is sometimes accurately referred to the seat of the intussusception-tumor, radiating to other parts, but in the beginning of the case it is often more or less diffuse. Associated with the colicking pain retraction of the testicles has been observed in some cases. The tenderness in the intervals is more apt to be localized, but frequently it is also diffuse, and seems to be situated in the abdominal muscles, especially when the disease has lasted for some time. Pressure increases the pain if it is actively present, contrary to the general theory that the pain is less when the bowel is empty, and they may bring on an attack during the intervals. When the intussusception has sloughed the pains cease, and they are generally at their worst just before sloughing takes place. It is possible even for the colicky pains to disappear, being replaced or masked by the general pain of the new complication.

State of the Bowels.—Next to the presence of a tumor, and the paroxysmal pain, the most characteristic symptoms of intussusception are those furnished by the state of the bowels. In the acute cases, as a rule, diarrhœa is present at first and constipation later, but in some cases these two conditions alternate at short intervals, and this alternation is very common in the chronic cases of intussusception. In Rafinesque's collection of chronic cases the stools were normal throughout, or easily moved by laxatives, in 7 cases; constipation prevailed in 12; diarrhœa in 16; and the two latter conditions alternated in 11 cases. In 6 cases of chronic intussusception of the small intestine, he found that diarrhœa was not present once. In children the proportion of cases of diarrhœa is said to be greater than in adults. According to Treves, constipation, that is, an absence of fæcal matter from the stools, is a marked symptom in only thirty per cent. of the cases of all ages. But Henoch [illegible] states that absolute constipation is the rule in children, no fæcal matter being contained in the frequent evacuations of mucus and blood. This difference of opinion makes it worth while to quote Leichtenstern's figures upon this point in full.

In 108 cases in the first year of life, Leichtenstern found that 104 had stools of blood and mucus, 25 had blood alone, 3 had constipation with occasional passages of blood, and in one case only was there diarrhœa without blood in the stools. On the other hand, in 185 cases over one year old, 101 had stools of blood and mucus, 39 were constipated from the beginning and 21 of the first set became constipated later, with occasional bloody passages, while diarrhœa without blood in the stools was present in 15, and alternating diarrhœa and constipation in 10.

The characteristic passages of acute intussusception are small, and contain mucus and blood, and they may be very frequent, closely resembling an attack of dysentery. These passages are found even when no fæcal matter comes away. The quantity of blood in the stools is very variable, from a mere streaking of the fæces to large clots, and the amount may even be so great as to cause death. Sometimes the small, frequent stools consist of pure blood without mucus. Bleeding is generally more marked in the beginning of the disease, but it also accompanies the casting off of the slough, and alarming quantities of blood may be lost at this time. According to Treves, blood is present in the stools in four-fifths of the acute cases, and according to Rafinesque it is found in only half of those which run a chronic course. It is more common in children than in adults, and in intussusception of the large than of the small intestine, but the latter fact may be a sequence of the former, owing to the rarity of enteric intussusception in children and to the greater frequency of intussusception of the large intestine on the whole. Sloughing is generally preceded by complete constipation, and followed by the sudden appearance of bloody stools and very offensive loose passages.

In many cases, chiefly those intussusceptions which have passed low down in the colon, and very rarely when the lesion is situated in the small intestine, there is tenesmus of the anal sphincter, or relaxation and even paralysis of that muscle. Leichtenstern looks upon the relaxation as secondary to the tenesmus. He found tenesmus in 104 cases out of his 593 (eighteen per cent.), and of these the intussusception was seventy-five times ileo-cæcal, fifteen times colic, and only four times was it in the small intestine. Rafinesque found tenesmus present in thirteen per cent. of his collected chronic cases. Treves reports that this symptom is present in fifty-five per cent. of all cases, and considers Leichtenstern's percentage altogether too low. The tenesmus is an early symptom, and it may be moderate, or so severe as to give the patient no rest and to cause prolapse of the mucous membrane of the rectum. It is most commonly met with among children, and this fact may be due to the frequency of intussusception of the large intestine at that age.

Dilatation of the anus is considered a pathognomonic sign of intussusception by Salzer,[illegible] and he says that it is present even when the tumor is high up in the bowel. In extreme cases several fingers may be passed into the anus with ease.

Vomiting.—Vomiting is most frequent in children, occurring among them in nearly all cases, and at an early period in the disease, but it is also common in adults. From Leichtenstern we extract the following figures:

Relation of Vomiting to the Age of the Patient.

	Under 1 year.	Over 1 year.
Vomiting present in	[illegible] cases.	[illegible] cases.
Vomiting only present in	7	3
Not noted, or absent in	4	[illegible]

Fæcal vomiting occurred in 53 cases over one year old and four times in those under one year; and hæmatemesis occurred twice in the first class and four times in the second. Vomiting is less frequent, less persistent, and less violent in intussusception than in other forms of intestinal obstruction. According to Treves it appears early in about three-fourths of the acute cases, and when it occurs in the rest it appears on the average about the third day, but in about eight per cent. of all the cases it is entirely absent. In chronic cases vomiting is rather less frequent. Thus in Rafinesque's collection of cases, out of 47 cases in which the symptom is mentioned it was altogether absent in 8; and in 7 others it was present only in the last stages.

The vomiting comes and goes without apparent cause. The vomited matter usually consists of the contents of the stomach or bile, and, according to Treves, it becomes fæcal in only about one-quarter of the acute and chronic cases, rather more frequently than was found by Leichtenstern. Very early and severe vomiting is most common in children, or in adults when the obstruction is in the small intestine. The frequency and severity of the vomiting seem to be dependent upon the degree of obstruction to the lumen of the bowel which may be present, and consequently the vomiting is apt to be severe when constipation prevails. Fæcal vomiting generally begins about the fourth or fifth day, and is most common in adults, and with intussusception of the small intestine. Vomiting of blood is noted in some rare instances, but these have generally been in chronic cases among children.

Among the curiosities of the subject, it may be well to note that in certain cases the appetite remains good, and isolated instances have even shown an increase of appetite—a voracious appetite, as the reporters of the cases describe it.

Course.—We have already explained the distinctions which are made between the various forms of intussusception according to their duration. We have seen that the peracute form runs its course with the symptoms of internal strangulation only, the forces of the patient being overwhelmed by the nervous shock of that condition, before any characteristic symptoms can be presented. The acute form of the disease begins more or less suddenly, and increases very rapidly to its extreme severity, and unless death then ensues simply from the exhaustion of the patient by pain, loss of rest and of food, some complications develop, and the subsequent course of the disease depends upon them. In a few rare cases the symptoms have disappeared as suddenly as they began, and the case has terminated in recovery—probably by spontaneous reduction of the intussusception. It makes but little difference whether the onset be very sudden or the symptoms begin mildly but quickly reach their height, for death is the inevitable result, unless they soon relax. When the strength of the patient is great, exhaustion may be delayed beyond the usual limit of time, and these cases may then be included in the subacute class, although they resemble in every other respect the acute form.

In the subacute cases there is more variety of evolution. In the beginning we may have very acute symptoms, or the symptoms may develop very gradually; while subsequently they may remain severe until the termination of the attack, they may diminish in severity very early and then remain moderate in character, or they may remain moderate throughout. If the violence of the symptoms is not too great, or too prolonged, the patient may retain strength enough to enter into the second term of the disease, and nature endeavors to save him by separating the intussusceptum by sloughing. As has already been described in the section on pathology, the sloughing usually results in the separation of the intussusceptum in one piece, although it may melt away by a slowly advancing gangrene beginning at the apex. When sloughing occurs the severity of the pain and nervous prostration diminish, but complete obstruction may be set up and no fæcal matter be passed, although the small passages of blood and mucus continue. Vomiting may be severe while this obstruction lasts. Then the slough gives way, sometimes so suddenly, and with such relief to the obstruction, that it is observed by the patient. Large amounts of blood may be lost at this time, and the stools are very fetid.

The removal of the intussusceptum restores the continuity of the bowel, and if no complication develops the patient soon recovers. It is evident that this method of cure requires time, usually from ten to fourteen days, and, if the strength of the patient is not sufficient to sustain him for that length of time, exhaustion will set in and cause death, just as it does when the patient has not sufficient resistance even to reach the stage of separation. As can be easily conceived, the dangers of this process of sloughing are very serious—from peritonitis, hæmorrhage, and sepsis; and cases are even on record in which the mass of slough was so great as to cause death by completely obstructing the calibre of the bowel at some point below.

Finally, the disease may run a chronic course, and here, too, we find a variety of modes of onset—sometimes acute, usually subacute, and occasionally, but rarely, a very gradual and insidious attack. It is evident that when the onset is very acute the symptoms must soon moderate, or the life of the patient would be promptly terminated. But they not infrequently retain a subacute character, and death results before many weeks have elapsed, seeming to be postponed simply by the great endurance of the patient, the cases closely resembling the subacute form both in symptoms and complications, and being separated from them by the rather arbitrary limit of time. In the ordinary chronic variety, however, after the symptoms have lasted in subacute form for a time they may almost disappear, leaving the patient quite comfortable, until an exacerbation sets in and the former history is repeated. The exacerbations become more and more frequent and the intervals grow less and less free from symptoms, and death finally comes from complete exhaustion, or by some complication, unless one of the exacerbations is sufficiently violent to terminate the life of the enfeebled patient in the same way as in a case of acute intussusception. Very rarely, if at all, does recovery ensue after the disease has passed into the chronic stage. In the chronic cases the symptoms during the intervals (pain, constipation, diarrhœa, and vomiting) are due to the mechanical obstruction to the lumen of the bowel, and resemble those of stricture of the intestine, bringing about a constant loss of strength by their interference with nutrition.

Complications.—The most frequent complication of intussusception is peritonitis, and it is usually caused by perforation of the bowel at the affected part, especially at the neck of the intussusception, although some cases are on record in which perforation occurred some little distance above, when the tumor had caused complete obstruction, with great distention of that part of the bowel. The peritonitis generally begins without warning, like ordinary perforative peritonitis, with a sudden and violent pain, often distinctly localized at first, but spreading quickly over the whole abdomen. The onset frequently takes place in one of the paroxysmal attacks of pain due to the intussusception itself. Severe shock accompanies the pain, followed by a rapid rise of temperature, vomiting, tympanites, and general abdominal tenderness. The usual picture of perforative peritonitis is thus presented, and the same fatal termination concludes the scene. Occasionally the peritonitis remains localized, all the symptoms being then of a milder type, but in time general peritonitis or septicæmia brings about a fatal result, except in those rare cases in which the intraperitoneal abscess bursts externally or into some of the viscera, and recovery is rendered possible by the establishment of a fæcal fistula. When general peritonitis develops the typical paroxysmal pains of intussusception disappear, probably because they are due to peristalsis, and the intestinal movements are paralyzed, or because they are masked by the pain of the peritoneal inflammation. But another form of peritonitis which it is important to recognize sometimes follows intussusception, although its onset is so insidious as to make the diagnosis difficult. This is the so-called peritoneal septicæmia, in which the inflammatory reaction of the peritoneal membrane is very slight, but the septic materials thrown out by the gangrenous gut are speedily absorbed, and give rise to a general septicæmia. In these cases there may be no tympanites, no pain, and no well-marked rise of temperature; in fact, the temperature more frequently falls slightly below normal. The patient complains less, for the sensibilities are diminished by the septic poison, but the vital forces have begun to fail, and in a few hours collapse sets in, and death comes with that surprising rapidity so often seen in cases of abdominal disease.

Septicæmia has been the cause of death in a few cases without the occurrence of any peritonitis, according to the post-mortem examination, but these cases may have been instances of the form just described. Abscess of the liver and general pyæmia are also possible results of intussusception, by means of a portal phlebitis. Besides the intraperitoneal abscesses mentioned above, abscesses might form from perforation of the colon into the cellular tissue, where no peritoneal membrane intervenes, resulting in a fæcal fistula, but there appears to be no such case on record. In fact, Treves states that he could find but one case of fæcal fistula of any kind following intussusception—which was that of a man who passed fæces in his urine for three or four months before his death.

We have already mentioned death by hæmorrhage among the dangers of sloughing. The tumor of the invaginated bowel may compress the bladder or ureters and cause anuria, hæmaturia, or even hydro-nephrosis. Or it may occlude the intestine by pressure, as has been observed in the sigmoid flexure and in the duodenum. Or it may cause œdema or even gangrene of the legs by pressure upon the great vessels. It is also possible that in some of the cases in which compression has been noted the effect was produced by the cicatricial contraction of masses of inflammatory tissue left after the intussusceptum had sloughed. In a few cases chronic diarrhœa has been observed, caused by obstinate ulceration at the point of sloughing, and it is said that stricture may be a sequel of this condition. The other complications of intussusception are simply those which are liable to occur in any acute disease, or in any chronic disease resulting in cachexia and malnutrition. The occurrence of pneumonia from the entrance of vomited material into the bronchi, and of intestinal obstruction due to bending of the bowel by adhesions after the slough has separated, need only be mentioned.

DIAGNOSIS.—In the diagnosis of intussusception it is necessary to consider the acute and chronic varieties apart.

Acute intussusception resembles more or less closely the other forms of acute obstruction of the bowels, but symptoms are generally present which render the diagnosis of intussusception the easiest among all the varieties of intestinal obstruction, except in the very acute form, which runs its course in a day or two, presenting scarcely any other symptoms than those of internal strangulation.

The different kinds of acute intestinal obstruction may be grouped for convenience of diagnosis under the following heads: (1) Internal incarceration, or stricture by bands, or through apertures; (2) volvulus; (3) gall-stones, or foreign bodies; and (4) intussusception.

Internal incarceration is marked by more violent symptoms of strangulation, and absolute constipation is the rule instead of the small and frequent stools of blood and mucus in intussusception; vomiting occurs early, and is more severe and constant than in intussusception; and pain is more continuous, although it has exacerbations which resemble the paroxysms of intussusception. Volvulus, although less acute in its first symptoms than is internal incarceration, is more acute than intussusception; the pain is more continuous, absolute constipation is the rule, and there is an absence of the characteristic stools of intussusception. There is usually no tumor in volvulus, but when there is one it is large, and has not the peculiar sausage shape of the intussusception tumor.

Occlusion of the bowel by gall-stones or foreign bodies is as a rule less acute in its course than intussusception; the constipation is absolute; the vomiting appears early, and is severe; and the pain is less intense, and more continuous than in intussusception. In the case of obstruction by a gall-stone there will be the history of previous attacks of biliary colic without obstruction, of hepatic disorder, and of peritonitis in the neighborhood of the gall-bladder, for stones large enough to cause intestinal obstruction are compelled to gain access to the bowel by ulceration, or by the formation and perforation of an abscess. In the case of foreign bodies there will also be the history to guide one. There may be a tumor in these cases, if the gall-stone or foreign body can be felt through the abdominal wall, but it will not have the shape and other characteristics of the tumor of intussusception. All of these varieties of obstruction are very rare in children, and all but internal incarceration are less common than intussusception, even in the adult.

Recapitulating the symptoms of intussusception by way of contrast, we find it occurring most frequently in children, beginning without warning, with intense abdominal pain coming in paroxysms which increase in severity for a certain time, and then grow milder. There is some shock, which may be severe, but is generally less so than in internal incarceration and volvulus. Vomiting is not very marked. There are frequent passages of small quantities of blood and mucus, and fecal matter may be absent in the stools during the entire course of the disease. The anal sphincter is often in tenesmus or dilated. A slight rise of temperature is common, especially in children. A sausage-shaped tumor is generally to be felt in the abdomen, advancing toward the anus with the progress of the cases. Finally, there is discharge of a slough.

Perityphlitis and perforative peritonitis have not infrequently presented the symptoms of acute intestinal obstruction, and laparotomy has even been performed under the erroneous diagnosis. In some cases the symptoms have been similar to those of intussusception, and it seems probable that some of the supposed spontaneous resolutions of intussusception, which occurred, were really instances of perityphlitis or typhlitis ending in resolution. The distinction of these diseases from intussusception should, however, be far easier than from some of the other forms of obstruction. Perityphlitis would generally present a less acute beginning, the pain would not be paroxysmal, constipation would be the rule instead of the mucous and bloody passages of intussusception; tenesmus would be rare, and there would be a totally different sort of a tumor—large, rounded, tender on pressure, and immovably fixed in the right iliac fossa, where the tumor of intussusception is seldom found. Perforative peritonitis would generally be more acute in its onset than intussusception, the shock would be more severe, the subsequent rise of temperature would be greater, and the pain more continuous; tympanites and abdominal tenderness would appear earlier, and there would be no tumor, and no dysenteric passages.

The symptoms of acute intussusception have a certain resemblance to those of dysentery and even cholera, although it would be unlikely to be taken for the latter except in the presence of an epidemic of the disease. Dysentery would be marked by greater tenesmus, unless the tumor of intussusception were actually in the rectum (and then it would be detected by examination); the pain would be referred to the rectum, and would be distinctly associated with the stools and tenesmus; fever would be more constant than in intussusception, and there would be an absence of shock. Cholera would be distinguished by the absence of abdominal pain, the presence of cramps in the limbs, the watery character of the diarrhœa, and the large size of the dejections. In both cases there would be no tumor to be felt in the abdomen or rectum. In both cases, too, the onset of the disease would be less acute, and would be initiated by a diarrhœa without pain, or at least with only the ordinary pains of colic.

Although the diagnosis of acute intussusception is comparatively easy, the recognition of the chronic form appears to be particularly difficult, if we are to judge from the fact that in Rafinesque's 66 cases the diagnosis was made only ten times, and even in the latter cases erroneous opinions as to the nature of the disease were held for some time by those in charge. The diseases with which chronic intussusception is most likely to be confused are the chronic forms of obstruction of the bowels (fecal impaction, stricture, and cancer), chronic dysentery, tubercular enteritis and peritonitis, lead colic, biliary colic, chronic diarrhœa, dyspepsia, and prolapse or polypus of the rectum.

Fecal impaction generally produces less severe constitutional depression than intussusception; it is found in elderly persons, and especially in women; it is of gradual development; and although alternating diarrhœa and constipation are sometimes seen, the diarrhœa is wanting in the blood and mucus which are found in intussusception. There is no pain and no vomiting. No small sausage-shaped tumor is discovered on examination, but the distended colon is often to be felt—full of hardened feces. Stricture of the small intestine produces symptoms which are very similar to those of chronic intussusception, especially if the lesion be situated high up in the bowel. But here, too, the beginning of the disease is gradual, the stools seldom contain blood or even mucus, there is seldom pain unless acute obstruction develops, and no tumor can be felt.

Cancer of the intestine, especially the annular form causing stricture in the large intestine, if low down, will closely resemble a chronic intussusception, with alternating diarrhœa and constipation, the presence of blood and pus, or muco-pus, in the stools, and attacks of abdominal pain. But no tumor can be felt in the early stages of the disease, and in the later stages the tumor is chiefly made up of adherent and thickened loops of intestine, and presents an irregular shape and an uneven surface of considerable extent. The pain is less paroxysmal, and might be better described as constant with exacerbations. If obstruction is caused, although it may be of the most acute kind, it is, as a rule, more like fecal impaction, while intussusception in its exacerbations generally reproduces more or less faithfully the symptoms of the acute variety. The mucous element is less prominent in the stools, and the blood is apt to come in larger quantities.

The distinction between an intussusception tumor in the rectum (whether it is formed in that section of the bowel or descends into it from above) and a polypus growing in that locality, as well as the diagnosis between an intussusception which has prolapsed and a simple prolapse of the rectum through the anus, must be made by careful examination of the parts. The slit-like opening in the apex of the intussusception, completing the resemblance of the latter to the portio vaginalis of the uterus with its os, and the attachment of the intussusception to the bowel in its entire circumference, will distinguish it from a polypus. The fact that the finger can be passed between the margin of the anus and the intussusception, while in simple prolapse of the rectum the outer surface of the prolapsed part is continuous with the mucous membrane or the skin at that point, is sufficient to assure a diagnosis in the latter case. But it must be borne in mind that, on the one hand, a polypoid tumor in the rectum may be the cause of an intussusception, and, on the other, an intussusception high up in the rectum might cause a prolapse of the rectal mucous membrane through the anus. Therefore, if there are symptoms of intussusception, and physical examination reveals a polypus or simple prolapse of the rectum, care must be taken to exclude the possibility of an intussusception in addition.

It is scarcely necessary to go over in detail the other diseases mentioned above as liable to be mistaken for chronic intussusception, for the simple recollection of the fact that there is danger of such errors should put the physician sufficiently upon his guard to recognize the true nature of the case. It is also unnecessary to mention that the elimination of a slough will be absolutely pathognomonic of the disease, for it can be easily distinguished from the shreds and casts passed in the rare membranous enteritis.

Diagnosis of the Site.—The determination of the locality of the intussusception is by no means so easy as was at one time supposed, but in certain typical cases it is possible to settle this point from the symptoms alone. We have seen that in children under one year the ileo-cæcal and colic intussusceptions form nearly four-fifths of the cases, and in persons over five years only one-half. The older the individual, therefore, the greater will be the chance of an intussusception in the small intestine, which is very rare indeed in young children.

Rectal tenesmus and relaxation of the sphincter ani are symptoms almost entirely confined to ileo-cæcal and colic intussusceptions, but they may also be found in the ileo-colic form when the tumor has advanced into the lower part of the colon. The stools afford us some clew, for complete obstruction is common in intussusception of the small intestine, and diarrhœa in that of the large. Blood is more frequent in the passages in those forms which involve the colon, and especially in the ileo-cæcal variety. As a rule, the onset of the disease is most sudden, and the shock is greatest, in the enteric and the ileo-colic forms. The pain, too, is more severe, and the paroxysms come at shorter intervals when the lesion involves the small intestine, or is of the ileo-colic variety.

Vomiting is more severe, appears earlier, and is more continuous in the enteric and ileo-colic intussusceptions. It is said by Treves never to be fæcal in the enteric cases, but in Cruveilhier's case of intussusception of the duodenum the vomiting is described as fæcal, and it is often impossible to draw a sharp line between vomiting which is fæcal and that which consists simply of altered bile. There can be no question, however, as to the general truth of the statement that true fæcal vomiting is not seen in obstruction of the bowels which is situated very high up. Another fact in regard to the vomiting is important in respect to the determination of the site of the intussusception, and that is the relief afforded to the symptoms by copious vomiting when the obstruction lies near enough to the stomach to allow the distended bowel to be efficiently emptied by the evacuation of the collected material in that direction.

The tumor will be small in intussusceptions of the enteric and ileo-colic varieties, and large in those involving the colon; and in the latter forms it will generally be found in the course of that part of the intestine, whereas it may occupy almost any position, and will be more freely movable, when the lesion is situated in the small intestine. As the tumor has been recognized in only twenty-four per cent. of the cases of intussusception of the small intestine, against sixty-one per cent. of the ileo-cæcal and fifty-two per cent. of the colic intussusceptions, the mere fact that a tumor has been discovered is in favor of the latter forms. The presence of the apex of the intussusception in the rectum is, of course, impossible in the enteric, and rare in the ileo-colic forms. No reliable conclusions can be drawn as to the situation of the intussusception from the time of appearance of the tympanites, or from its character, for reasons given elsewhere.

From these facts, in cases which begin suddenly and acutely, with great shock, severe pain, short intervals between the paroxysms, nearly complete obstruction of the bowel, early appearance and persistency of the vomiting, and especially if the vomiting affords distinct relief to the symptoms, we may assume that the obstruction is high up in the intestinal canal, and this assumption is rendered certain by the recognition of a small movable tumor in the abdomen.

On the other hand, when an ileo-cæcal or colic intussusception occurs, the beginning is apt to be less acute, the pain less severe, the intervals between the paroxysms longer and freer from pain, the obstruction of the bowels less complete, and vomiting not so common or persistent —at least in the early stages. Tenesmus of the rectum is present in these cases, and the tumor is large, often immovable, lies in the course of the colon, and may be felt in the rectum.

PROGNOSIS.—The general prognosis of intussusception is very bad. Leichtenstern gives the mortality as seventy per cent. Rafinesque found only nine recoveries in his series of 59 chronic cases; and in three of these the diagnosis was doubtful, spontaneous recovery having taken place, while in three others recovery was obtained by laparotomy. If the doubtful cases are excluded, his mortality might fairly be placed at ninety per cent.

The two factors which are most important in determining the prognosis in any case are the age of the patient and the situation of the intussusception. The following table, from Leichtenstern, shows that the mortality is greatest among the very young, and least between ten and fifty years of age. It also indicates that the difference is caused by the varying frequency of sloughing, for in the last column is given the percentage of mortality in those cases in which sloughing did not take place, and it will be seen that it remains nearly constant for all ages.

Mortality according to Age.

Age.	General mortality.	Mortality when sloughing did not occur.
	Per cent.	Per cent.
1 to 6 months	88	86
6 to 12 months	82	
1st to 10th year	72	80
11th to 20th year	63	86
21st to 40th year	63	82
41st to 50th year	63	80
50th to 60th year	71	
Over 60 years	77	..

In 408 cases in which sloughing did not occur, the mortality was eighty-five per cent.; in 149 cases in which it took place, forty-one per cent died.

If we omit the cases under eleven years, of which nearly all were ileo-cæcal intussusceptions, we obtain the following figures from Leichtenstern, showing the mortality for each variety of intussusception and the proportion of cases in which sloughing occurs in each, and again we find a distinct relation between the two.

Mortality according to the Location of the Intussusception.

Variety.	Mortality.	Sloughing occurs.
	Per cent.	Per cent.
Ileo-cæcal	72	20
Colic	70	28
Enteric	58	61

Sloughing is almost unknown in the ileo-colic intussusceptions. When sloughing occurs, the mortality is about the same for all varieties. Without sloughing the mortality would probably be greatest in the enteric intussusceptions, but the diagnosis in these cases is so uncertain, unless it is proven by the passage of a slough, or by a post-mortem examination, that there are no figures to be depended upon as regards this point.

Sloughing with elimination of the slough occurs in about forty-three per cent. of all cases. Excluding those under six years of age, it takes place in fifty-four per cent. of the female patients against only thirty-one per cent. of the males, according to Leichtenstern. The same authority gives the total mortality of sixty-eight per cent. in males, and seventy per cent. in females, which would indicate that although separation of the slough occurred more often in women than in men, a larger number of women died from the subsequent complications of the process.

The separation of the slough depends upon the age of the patient, and the mortality after it has occurred is also affected by the same factor, as Leichtenstern shows by the following figures:

Relation of Age to Separation of the Slough.

Age.	[illegible]	Mortality after sloughing.
	Per cent.	Per cent.
1 to 12 months	[illegible]	
1st to 5th year	[illegible]	
5th to 10th year	[illegible]	12
10th to 20th year	[illegible]	[illegible]
20th to 30th year	[illegible]	[illegible]
30th to 40th year	[illegible]	[illegible]
40th to 50th year	41	[illegible]
Over 50 years	[illegible]	[illegible]

The least mortality after sloughing takes place is found between ten and fifty years of age, and, taken in connection with the table above given, the figures show that the high mortality in infants depends upon the rarity of sloughing, while in old age and in children it depends upon the complications which develop during sloughing, or upon lack of the necessary strength for recovery when it is complete. It would appear that in children under one year recovery was impossible unless treatment succeeded in reducing the intussusception; and that even up to the age of five years recovery seldom occurred, unless under the same condition.

Separation of the slough generally takes place between the tenth and twenty-first days; but in children the average time is somewhat earlier—from the fifth to the tenth day. As a rule, separation is effected more quickly in the intussusceptions of the small intestine than in those of the large. In chronic cases sloughing very rarely takes place, contrary to what would naturally be supposed, and contrary to the statements of authors before Rafinesque. The latter authority found but six cases of elimination of the slough in fifty-six cases of chronic intussusception, and recovery followed in only two of these.

It cannot be too strongly emphasized that sloughing is by no means equivalent to recovery, for we have seen that 41 per cent. of the cases in which the slough is eliminated perish from the complications dependent upon that process, or are so exhausted by their severe illness that they are unable to complete the recovery which is thus begun. The prognosis will, therefore, depend in great part upon the complications, for if peritonitis develops, a fatal termination is almost assured. Passing by the less common modes of death, such as septicæmia and hemorrhage, the two main causes of death are peritonitis and shock or exhaustion. In children, most of the deaths are the result of shock or exhaustion, for perforation of the intestine, or peritonitis without perforation, was found in only six cases by Leichtenstern, while in one hundred and seventy-five cases over one year of age peritonitis was the cause of death in twenty-four per cent.

The proportion of deaths from peritonitis varies with the seat of the intussusception, being thirty-seven per cent. in the ileo-cæcal form, twenty-two per cent. in the enteric, fourteen per cent. in the colic, and only three-fourths of one per cent. in the ileo-colic. The extreme rarity of perforation in the ileo-colic intussusceptions, and its frequency in the ileo-cæcal, are due to the different course of the disease in these varieties, for the ileo-colic cases die of shock before peritonitis can set in. This is proven by the fact that perforation takes place on the average in fifty-seven days in the ileo-cæcal intussusceptions, and in twenty-four days in the enteric—both periods being longer than the average duration of life in these forms, showing that perforation occurs only in cases with a prolonged course. The rarity of perforation in the colic, however, must depend upon a different cause, for a chronic course is the rule in these cases. Leichtenstern attributes it to the greater thickness of the wall of the large intestine as compared with that of the small; but it seems more reasonable to seek the cause in the larger calibre of the bowel, and the consequent diminished liability to strangulation.

The time of death in the fatal cases is influenced by the age of the patient, as appears by the following table from Leichtenstern, which shows that the shortest and most rapid course is found in children, especially during the first year of life. This result agrees with other facts which have been pointed out, especially that death in children is caused by shock, and that the most acute cases are the most fatal.

The Time of Death and its Relation to the Age.

Time of death.	Age.								
	0-1 year.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Over 60 years.	[illegible]	[illegible]
1st day	[illegible]				[illegible]				[illegible]
2d day	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
3d day	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]
4-7 days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2d week	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]
3d week	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
4th week	[illegible]	[illegible]	[illegible]		[illegible]	4	[illegible]	[illegible]	[illegible]
2d month	2	[illegible]	2	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	2			[illegible]	[illegible]			[illegible]
[illegible]					[illegible]			[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]				[illegible]
[illegible]					[illegible]				[illegible]
[illegible]					2			[illegible]	[illegible]
1-2 years							[illegible]	[illegible]	[illegible]
Over 2 years						[illegible]			[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]

The mode of onset does not assist us in estimating the prognosis in any case, for we have already seen that the most chronic cases may begin very acutely, and, at the same time, cases which will run their course very rapidly may have a very mild beginning. But in so far as acute symptoms at the outset indicate the greater probability of an ileo-colic or enteric intussusception, just so far an acute commencement of the disease is a bad sign.

The exact effect of treatment upon the prognosis of intussusception is as yet undecided, but it will be considered when discussing the various forms of treatment, at least, as far as it is possible to do so at the present time. It may, however, be briefly said here that the results of laparotomy are not so good as it was hoped some years ago that they would be, for the mortality appears to be seventy-six per cent., which is worse than the general mortality of seventy per cent. which is given by Leichtenstern. Undoubtedly these results can be improved in the future. The results of treatment by injections appear to be better, but there is as yet no accessible material for determining its real value in figures.

TREATMENT.—*Expectant and Medicinal.*—Brinton is the chief advocate of leaving the case to nature in the hope that sloughing will take place and recovery become possible, for spontaneous reduction of the intussusception is such a rare event that it is scarcely worth while to take it into consideration. If spontaneous reduction occurs at all, it will take place very early, unless the whole course of the case is very mild. But many case a posttive diagnosis will scarcely be possible, unless a tumor has actually been discovered in the abdomen. The treatment to bring about spontaneous resolution would be the same as that adopted when it is intended to wait for sloughing.

The first necessity is the avoidance of purgatives, for they tend to increase the spasm and even to enlarge the intussusception. We have seen that Leichtenstern found two cases in which the displacement had been brought on by purgatives. It is true that some cases of recovery from intussusception have been claimed for the use of purgatives, and we have seen that some of Nothnagel's experiments tend to support this belief. But even in the most striking case of the kind, reported by Wilks,[23] which occurred in a girl with intestinal obstruction and a tumor in the abdomen, the diagnosis is not beyond suspicion. The use of metallic mercury must be classed with the purgatives, for its action is due either to increased peristalsis or to mechanical pressure upon the tumor—both acting in the wrong direction, and tending to drive the mass farther on in the bowel.

The only permissible medication is the administration of opium and belladonna, to quiet spasm of the intestinal muscle. Belladonna has been recommended by many for the regulation of the peristaltic movements, but it is not a powerful drug in this direction, and its action is so uncertain, and the idiosyncrasies of patients toward it in doses of any size are so common, that it is not often employed except as an adjuvant to opium. Opium is the only drug which is of any value in the treatment of intussusception. Nothnagel's experiments upon rabbits have shown that morphine in moderate but full doses stimulates the splanchnic nerve, but in very large doses paralyzes it. This nerve is inhibitory to peristaltic movements; therefore its stimulation diminishes these movements, and its paralysis increases them. Consequently, opium affords the readiest means for controlling the intestinal movements and for relaxing spasm, and as the pain depends upon the contraction of the intestinal muscle we have in it a practical guide to the amount of the drug which is needed. The hypodermatic administration of morphine is the best method of using the drug, for the stomach often will not retain medicines, and the frequent passages and tenesmus interfere with their introduction by the rectum. There is one danger to be guarded against, at least in the early stages of the disease, namely, the possible spontaneous reduction of the intussusception, removing the stimulus of pain while a large amount of the drug is yet in the system, and resulting in poisoning. In adults this danger is not a very threatening one, but in children it is of the greatest importance, for opium is a more dangerous drug to them than to adults. Another danger in the employment of opium is that its favorable effect upon the pain and the more obvious symptoms will deceive the patient, and lull the physician into a false security, even when the latter has no faith in the drug except as a palliative. This apparent improvement may delay any active attempts to reduce the intussusception until it is too late, and thus result in the death of the patient.

The proper administration of the food is a very important factor in the treatment of subacute and chronic intussusception, and although the short duration of the acute form makes it less important in the management of such cases it should not be neglected even in them, for it is never possible to predict what the ultimate course of the disease may be. The food should be of such kinds as will be easily digested and absorbed by the stomach, leaving as little residue as possible to be disposed of by the intestine. Therefore milk, broth, soft-boiled eggs, and partially digested foods must be relied upon, and even these must be given in small quantities at short intervals, rather than in large amounts less frequently. Owing to the numerous passages and the tenesmus, and the danger of exciting undue peristalsis, it will not be advisable to use the rectum for feeding purposes, except, as has been suggested, by employing nutrient substances in the large injections when they are employed to reduce the intussusception. It will often tax the skill of the physician to the utmost to maintain the strength of the patient when the vomiting is troublesome, but fortunately the latter is by no means a constant symptom, and the morphine will often help to allay the irritability of the stomach. Probably the use of the stomach-tube and lavage will be of great assistance in improving the retaining power of the stomach in these cases, as well as in other forms of acute obstruction of the bowels. Stimulants must be employed as the indications arise, care being taken to give them in such form and so dilute as not to excite vomiting; and if the latter is uncontrollable, recourse may be had to subcutaneous administration.

When the separation of the slough is taking place, and for a long time after it has been eliminated, the greatest care should be exercised in the diet, in order to avoid rupture of the freshly formed adhesions. Anything which might excite strong peristalsis, such as purgatives, fruit, and green vegetables, must be strictly avoided; also any substances which might cause obstruction, such as indigestible portions of food, tendon, bone, and improperly cooked beans. More than one case is on record in which rupture was caused by errors in diet some months after the slough had separated, when recovery seemed complete.

Electricity.—From the experiments of Nothnagel it appears as if there were some ground for hope that an intussusception might be reduced by the use of electricity, if the current could only be carried in sufficient strength directly through the affected loop of bowel just below the intussusception; but the practical difficulties in the way seem insuperable. While repeating Nothnagel's experiments, the writer frequently observed that when an intussusception had been formed, a fresh application of the electricity at the same place as before caused the intussusception to reduce itself. In no case could the intussusception be made to increase by a second application of the electricity. But to produce these effects it is necessary to employ a current of considerable strength, probably stronger than the patient could easily bear upon the skin, especially when we take into account the loss which occurs as the current passes through the abdominal wall. Some recoveries have been claimed for electricity, but they are not of such a character as to compel belief in the method. Still it would be worth while to try the application of strong faradic currents upon any intussusception which lay near the abdominal wall. Although negative evidence is always of doubtful value, there is probably no danger of increasing the growth of an intussusception by the use of electricity. If the tumor can be reached by the rectum, one electrode should be applied to it within the bowel, while the other is applied to the abdominal wall above the tumor. If the abdominal wall were sufficiently flaccid to allow of grasping the tumor between the electrodes, the current might be passed directly through the intussusception, the electrodes being placed in position before the current was turned on. It is not probable that currents passed in the course of the pneumogastric or splanchnic nerves (by having one electrode upon the spine in the dorsal region, and one upon the abdomen) would have any effect, for currents strong enough to act with the necessary force upon these deep-lying nerves could not be safely employed. An ingenious but not very practical use of mercury in connection with electricity has been suggested, the idea being that when the mercury was administered by the mouth, it would collect above the tumor, and serve to direct the course of the electric current through the intussusception; but it is not certain that the mercury would reach that point.

Massage.—Manipulation of the abdomen has been frequently recommended for the treatment of various forms of intestinal obstruction, and especially for intussusception. We know by experiment that the intestinal muscle can be made to contract locally by mechanical irritation, such as a pinch or bruise, but this contraction remains localized, and does not develop into a peristaltic wave. Massage, however, does excite a general peristalsis in some cases of intestinal torpidity, acting probably by the application of the mechanical stimulus to successive portions of the bowel in turn, and in restoring the normal irritability of the intestinal muscle if this has been diminished. It is conceivable that massage might do harm in intussusception, rather than good, for if the tumor were still growing, anything which would excite more active peristalsis would possibly be as likely to increase the size of the tumor as to cause its reduction. An apparent contradiction to this supposition has just been noted in electricity, but this may be explained by the hypothesis that the electric current does not simultaneously affect all the layers of the intussusception, and waves of contraction, which run through one layer only, cause the reduction of the bowel. If the tumor is swollen from œdema or congestion, it is possible to reduce the size of the whole mass by energetic compression with the hand, which renders its solution [illegible] likely. It can be imagined also that simply pushing the tumor to one side might tend to draw out the invaginated bowel, by pulling upon the mesentery which has been dragged in with it; or even that the bowel above or below the intussusception might be held stationary against the spine or some other fixed point, and then the tumor could be pulled upon or pushed aside in such a way as to exert traction upon the intussusceptum, or even to squeeze it out from below. But these manœuvres must be carried out through the entire thickness of the abdominal wall, and are therefore too vague and uncertain to make it worth while to persist in them, if speedy relief is not obtained. Probably, after all, the principal benefit of massage lies in exciting increased peristalsis.

But although massage probably cannot accomplish much when employed alone, it is very useful in connection with inflation or injection of the bowel. Here the conditions of the problem are somewhat altered, for there is a force below the intussusception which is tending toward reduction and the massage assists this force by exerting additional pressure upon the enclosed air or fluid, and by giving short lateral, rocking movements to the intussusception, which favor its reduction—just as such movements favor the drawing of a nail from wood, or the slipping of any tightly wedged bodies. The presence of this pressure from below also prevents any peristaltic movements of the bowel which may be excited by the massage from increasing the growth of the intussusception. But massage must be employed with great caution if lapse of time, or very severe symptoms, gives us reason to believe that the coats of the bowel have been softened. Nothing would be easier than to produce a tear even in perfectly sound intestinal walls by too violent manipulations, and especially if considerable pressure were already being exerted from below by injection or inflation of the bowel.

Injection and Inflation.—Injection of the bowel is one of the oldest methods of treatment in intestinal obstruction, and in no case does it promise so well as in intussusception. Given a section of the bowel which has been invaginated into that just below it, what easier or more reliable way for returning it could be found than the injection of water or air from below? What mechanical device could be more perfect than the penetration of the fluid into the space between the middle and external layers of the intussusception, thus distending the sheath and compressing the intussusceptum, while at the same time it presses the latter upward, the pressure being evenly diffused over the entire surface of both? It has been objected that injection would tend to increase an ascending intussusception, although Rokitansky claimed that injections would reduce the ascending as well as the descending; and one of Nothnagel's experiments on ascending would seem to show that he was right. Practically, however, ascending intussusceptions are so rare in the clinical form that we can afford to disregard them.

The first question which suggests itself is as to the amount of pressure which the bowel will bear. We know that there are instances in which spontaneous rupture of the gut has been observed in intestinal constriction, even when the wall had not been weakened by ulceration, but as a rule it will bear a very considerable pressure when healthy. But very few exact observations are at hand for determining the amount of this pressure, the only facts which I have been able to discover bearing upon this point being the following: Forest[illegible] made some experiments upon cadavers (three of four infants, an eight months fœtus, and one adult), and reached the conclusion that the colon of a child would bear a pressure of eight pounds to the square inch without rupture, and that of an adult would bear twelve to fifteen pounds. His experiments appear to have been made after the abdominal cavity had been freely opened. Rosch[illegible] had a case of [illegible] ileo-cæcal intussusception in a child, in which he employed the pressure of a column of water [illegible] feet high, without success; and after death a pressure of [illegible] also failed to reduce the intussusception, the bowel bursting at this pressure, half way between the anus and the ileo-cæcal valve. This experiment agrees with those of Forest. We are told by one observer that he connected the tube of a Davidson bulb-syringe with a siphon of carbonated water, inserted the nozzle of the syringe in the rectum, and when he opened the valve of the siphon, the pressure was so great that he was unable to compress the bulb of the syringe with his hand; and yet he did not rupture the gut, and cured his patient. We may, I think, accept the limit laid down by Forest, that a pressure of six pounds to the square inch can be safely employed in children as long as the bowel is probably in a healthy condition.

This force is sufficient in most cases to reduce the intussusception, for although there are very few cases reported in which data are given from which the force employed can be computed, we have two cases reported by Bayliss[illegible] in which the pressure of a column of water not over five feet high (giving a hydrostatic pressure of only about two pounds to the square inch) reduced the intussusception—which recurred in each case, it is true, but ended in eventual recovery. Putnam[illegible] also reports a case cured by the use of the same amount of pressure.

But it is self-evident that a pressure which would be safe while the bowel retained its original strength, will not answer when it is weakened by the changes resulting from impaired circulation, and therefore the problem does not admit of a purely experimental solution. We have seen that in some cases these changes take place very early, and in others they do not occur until a very late period, but some indication of their intensity can be gained by considering the course of the symptoms. It is generally allowed that in the acute cases the changes may be very considerable within forty-eight hours, while in the subacute cases they are not decided for from five to seven days and in the more chronic cases they may be slight even after the lapse of several weeks. Leichtenstern found the time at which reduction was made, given in 41 of his cases which recovered, and 29 of these cases were reduced during the first week, 6 in the second, and 4 in the third, while one case is reported by Wilks[illegible] of successful reduction after seven weeks—a doubtful case of spontaneous reduction. These limitations may be accepted as broad working rules, and in doubtful cases the treatment must be applied tentatively, without anæsthesia, in order to use the feelings of the patient as a guide. But it must not be forgotten that the feelings of the patient are not very reliable, for in passing through the structure of the rectum, the latter has frequently been perforated, and the peritoneal cavity opened, without causing unusual pain at the time. Fecal passages and much blood passed in the stools should contraindicate all attempts at reduction, for they show that the strangulation is severe, and that sloughing has probably begun.

Some claim that air is far better than water as an injecting material, and others prefer carbonic acid gas. While it is true that air is more compressible and therefore would give a more elastic pressure, it is much more difficult to use it with measured force, and water is therefore to be preferred, for by the employment of the siphon or fountain-syringe apparatus, consisting of a long rubber tube and funnel, the force admits of exact measurement and control. If the nozzle of the syringe is of sufficiently large calibre, the only effect of a sudden contraction of the muscles of the intestine or of the abdominal wall would be to return a portion of the injected fluid, and the hydrostatic pressure is sufficiently elastic for safety. The local sedative action of carbonic acid gas upon the intestinal muscle is probably not sufficiently powerful to be worthy of consideration. The claim that air or gas would be less irritating to the peritoneum than water, in case a rupture took place, may also be disregarded, for the active irritant in case either should enter the peritoneal cavity would not be the air or water itself, but the fecal matter which would pass in with it from the bowel. It has been recommended by some to use tobacco enemata, but in morphine we have a drug which acts more powerfully upon the intestinal movements, and at the same time is much safer. The addition of purgatives to the injected fluid is of course forbidden in intussusception, for we do not desire to excite peristalsis. For the same reason the use of ice-water enemata is inadmissible, to say nothing of the shock to the enfeebled system which would be caused by the cold water. The suggestion to add nutritive materials to the injected fluid has already been mentioned.

The ileo-cæcal valve places a practical barrier to the employment of injections for reduction of intussusception of the small intestine. The much-discussed question, whether an injection can be made to pass the valve from below, seems to have reached an affirmative decision, at least for certain substances and in some subjects. It has been especially claimed for carbonic acid gas (v. Ziemssen), and for hydrogen gas,[39] that they will pass the ileo-cæcal valve under low pressure; but the difficulty does not cease here, for the innumerable turns of the small intestine act as valves and "traps," which constantly add new obstructions to the upward flow of the injected material, and diminish its pressure, so that it is not easy to conceive that it would retain sufficient force to reduce an invaginated loop of bowel. As we hope to be able to demonstrate that the dangers of laparotomy are not great enough to warrant much loss of time with doubtful means of treatment, or to justify the risk of using very great force in injection, we shall find it practical to limit the use of injections to the treatment of intussusceptions of the large intestine.

The selection of the best method of giving the injections requires careful study. As has already been shown it is necessary to measure accurately the force employed, and to keep it within certain limits. For this reason many of the ordinary means of giving the injections—the ordinary enema syringe, the siphon bottle of carbonated or aerated water, the bellows (for air), and especially the introduction of chemicals into the rectum, in order to generate gas within the intestine—must all be rejected as uncertain and dangerous. With these methods it is impossible to judge of the amount of force employed. The force exerted by a hand of ordinary strength compressing the bulb of a Davidson syringe is much too great to be safe, and as it is impossible to graduate this powerful pressure, this instrument should never be employed.

The siphon bottles of water charged with gas are particularly dangerous, for they are charged at a pressure of one hundred to one hundred and twenty pounds to the square inch, and although this force could be kept within bounds by allowing only a drachm or so of the liquid to enter the gut at a time, the surgeon would have no idea of the force actually employed. The most dangerous of all is undoubtedly von Ziemssen's suggestion to introduce bicarbonate of soda and tartaric acid into the rectum separately, and to generate gas by their combination. Even if the total quantity of gas produced is limited by the measurement of the salts introduced (according to Ziemssen twenty grammes of bicarbonate of soda and fifteen of tartaric acid will fully distend the colon in the adult), and by the introduction of these amounts in three separate portions, as recommended by him, the crudeness and dangers of the method are evident.

The only method worthy of consideration is the use of the simple tube and funnel, for it enables us to accurately determine, and easily control the pressure employed, and fortunately its simplicity allows of its improvisation and use in almost any locality. As has been shown above, a pressure of from eight to nine pounds is the bursting capacity of the colon in the infant, and from twelve to fifteen in the adult, so that we may safely employ a pressure of six pounds in the former case, and somewhat more in the latter, if the intussusception is sufficiently recent, and the symptoms sufficiently mild to warrant the supposition that the walls of the bowel are still in a healthy condition. As a column of water two and one-third feet in height gives a pressure of one pound to the square inch, an elevation of fourteen feet, measured from the level of the water in the funnel to the level of the intussusception will exert a pressure of six pounds, which is the force desired. Consequently the only apparatus needed will be a rectal tube of large calibre, a rubber tube fourteen feet long, and a funnel or irrigator for the upper end. It is well to have some extra tubing, for generally the ceiling of the room will not be high enough to admit of fourteen feet of elevation, and if the tube is long the funnel can be carried out of the door, and up a stairway until the desired height is reached.

In children always, and generally in adults, it will be advisable to employ anæsthesia, for although Nothnagel states that ether does not diminish the contraction of the intestinal muscle, it is well to remove the tension of the abdominal wall, for it certainly hinders reduction by pressing upon the intestinal contents above the intussusception. It is even possible that a sudden contraction of the abdominal muscles would so increase the pressure in the intestine distended with the injected fluid as to cause rupture, especially if there were no gas in the bowel to take up this increased pressure by its elasticity. Where it is feared that the wall of the gut is already weakened, it may be safer to inject without anæsthesia, as has been mentioned above.

The pressure of the injected fluid should be increased slowly, and in this way it will often be found that the intussusception has been reduced before the limit of permissible force has been reached. The injection should also be retained for twenty or thirty minutes when the limit has been reached, for occasionally the pressure does not take effect at once. In one case, in which the injection reduced an intussusception six inches long to three inches, and was then allowed to escape, examination of the remaining tumor, some time after, showed that it had spontaneously diminished one-half, and the small tumor still present was made to disappear by a little manipulation with the hand. This case shows that sometimes, when the reduction has been begun by the injection, it may go on spontaneously.

There is generally great difficulty in closing the anus so as to prevent the escape of the fluid, especially if there is any dilatation of the sphincter. Treves recommends Lund's apparatus, which consists of a hollow rubber ring inflated with air, through the centre of which the rectal tube passes. This ring is held against the buttocks by a stout handle, with a disk upon it, which compresses the ring against the skin. A useful apparatus is easily made by wrapping a roller bandage, about an inch wide, around a stout enema tube, so as to make a sort of conical plug, the apex of which is inserted into the anus with the tube. Putnam[40] describes an ingenious method of using the force of the injecting fluid to occlude the anus. He employed a soft rubber bulb, to which was attached on one side the enema tube, and on the other, the rubber pipe from the reservoir of fluid. The rectal tube was inserted and the soft bulb held against the anus, so that as the water flowed from the reservoir it first distended the rubber bulb and then passed into the rectum, the pressure in both places being the same. If the bulb was pressed against the anus with more force than the pressure of the water in the pipe, the water was forced back in the latter and the bulb collapsed and allowed the water to escape from the rectum.

Massage is a very useful adjuvant in the treatment by injection, and should always be employed in connection with it. Caution is necessary, however, for it must be borne in mind that the bowel is already distended, and a slight additional pressure might rupture it. The position of the patient has often been insisted upon as very important in administering injections, and indeed some cases have been reported as a result of simple inversion of the patient without the assistance of any other means. It is difficult to understand how changing the position of the patient could affect the reduction of an intussusception, unless it were in a case in which the tumor was very large, and perhaps the bowel loaded with faeces behind the obstruction, so that when the patient was suspended by the feet the weight of the tumor would carry it into the upper part of the belly and thus make traction upon the mesentery where it was shortened by being drawn into the tumor. But it is important to have the patient so placed that the tension of the abdominal muscles will be reduced to a minimum, and this can be done by flexing the pelvis and the thighs while on the back, upon the side, or in the gynecological "Sims" position.

There is one class of cases in which it is not advisable to attempt reduction of the intussusception by injections: this includes all cases in which no tumor can be felt, and the diagnosis has been made solely by the symptoms. In these it will be impossible to tell whether the efforts at reduction have been successful or not, and the surgeon might be led into employing a dangerous amount of force; hence an exploratory laparotomy is less dangerous for such cases. The proof of successful reduction is the disappearance of the tumor under the hand, which should be kept upon it during the injection to ascertain this fact. Some observers report a sort of gurgling sound which is heard at the moment of reduction, and nearly all have noted that a general distention of the abdomen suddenly appears as the injected water or air removes the obstruction and passes on into the bowel above. The patient, if conscious, has often remarked that the pain decreases as the injection progresses, and ceases entirely at the moment of reduction; and children will stop crying and fall asleep during the injection.

The percentage of recoveries brought about by injections is not known, but it is remarkable that many observers have reported groups of two or three cases treated successfully by this means. It is much to be desired that some sort of collective investigation by reliable men who have carefully observed cases should be made, in order to gain some definite idea of the real merits of the method.

We might class with injections the reduction of intussusception by sounds introduced into the rectum. This method is full of danger and should never be resorted to, at least with any force.

There remain to be considered the operative methods of treatment: Removal of an intussusception prolapsed at the anus by incision and suture, enterostomy, and laparotomy.

Amputation of a Prolapsed Intussusception.—An intussusception projecting from the anus has been removed by excision in several cases, generally owing to an error in diagnosis, the surgeon supposing it to be a polypus or, at the most, a prolapse of the rectum; but this has also been done intentionally, and the results have sometimes been very good. If the diagnosis has been made and the tumor is entirely outside of the body, it is certainly wise to remove it. This is best accomplished by circularly incising the bowel a little above the tumor by short cuts, following each extension of the incision immediately by sutures, uniting the coats of the bowel above the invaginated part to the rectum just inside the sphincter of the anus. In this way the peritoneal cavity is not broadly opened, and there is no danger of prolapse of other loops of intestine.

Enterostomy.—Enterostomy has very seldom been performed in intussusception. When done in the ordinary way, simply making an artificial anus above the intussusception, it is obvious that it could only give relief to the pressure of the pent-up contents of the bowel above, and thus allow life to be prolonged until the slough could be eliminated. Not infrequently the surgeon does not see the patient until he is in extremis, and any other treatment is out of the question, so that this operation undoubtedly has its place, and should not be rejected because the results have hitherto been unsatisfactory. There can be no question that when the patient is in collapse a laparotomy is but little more than an autopsy held before death, and that it gives the patient no chance of recovery. Enterostomy, on the other hand, would at least do no harm, and in some of these cases in which the intestinal obstruction was the principal element it would certainly do good. In cases in which strangulation was the marked feature, and there was no perceptible collection of fecal matter, enterostomy could of course do nothing to relieve. Some would exclude enterostomy from consideration in the case of children, because of the fact, already shown, that a slough is to be expected in only two per cent. of the cases under a year old. But even at this age, when no tumor can be felt which can at once be cut down upon, securing a very short operation, and when the patient is too feeble to endure a full exploratory laparotomy, it would be better to try what simple relief to the obstructed intestinal contents would accomplish, rather than leave the child to its fate. Although the proportion of cases at this age in which the slough separates is so small, and although the reason for this fact is the early and severe strangulation, it may be that in some cases the little patients have not sufficient strength to carry them through the period of obstruction which precedes the discharge of the slough, and enterostomy would undoubtedly give such cases a chance of recovery.

Braun in his study of intussusception,* gives thirteen cases of enterostomy performed for intussusception, and to these I have been able to add three others ([illegible]), making sixteen cases in all. Of these, eleven cases died, and five recovered. In two of the successful cases the diagnosis might be questioned, but the other two admit of no doubt, for in one there was a slough passed, and in the other the presence of the intussusception was verified by exploration of the abdomen at the time of the operation. In four of the cases which recovered, the intussusception appears to have undergone spontaneous resolution when the pressure upon it by the faeces collected above was removed, and as one of these was the case in which the intussusception was verified at operation, there can be but little doubt that an intussusception can recover in this way. It is not fair to include in the statistics of enterostomy those cases in which laparotomy was performed, and an artificial anus made in addition, a class of cases in which there is as yet no recovery on record. In all the cases of this group the operation was so long postponed that the strength of the patient was entirely exhausted, and yet he was subjected to the shock of a prolonged operation, with efforts to reduce the intussusception, before the artificial anus was made. We need not fear that the artificial anus will be permanent in these cases, for, according to the study made by the writer,* of the cases which recovered after enterostomy had been performed for acute intestinal obstruction, sixty per cent. regained the natural course of the faeces and the anus then closed spontaneously, or was readily closed by a plastic operation. It is to be hoped that the cases for which enterostomy is suited will constantly diminish, by the more systematic use of injections, and by the earlier resort to laparotomy, but probably there will always be some cases in which it will be indicated.

Laparotomy.—We come finally to the vexed question of laparotomy in the treatment of intussusception. What surgeon who has seen how easily intussusception can be unravelled in his hands at the autopsy table, when the adhesions are not strong, and then has been brought face to face with the same condition in the living, has not longed to get the invaginated bowel within reach of his hands, instead of trusting to the relaxing effect of chloroform, or the blind use of injections? But even in these days, when the fear of peritonitis no longer deters him, a more subtle enemy remains unconquered, and owing to the effects of shock, the mortality of these operations still remains very high.

In 36 cases of laparotomy performed for intussusception, of which 30 were in children, Braun found 25 recoveries, and 40 deaths—a mortality of 78.4 per cent. In 27 of these cases, however, in which the intussusception could be reduced at the time of operation, 11 recovered and only 16 died, two-thirds of these cases being children, and four of the recoveries occurring in them. His collection of cases includes a few chronic intussusceptions, in which the mortality is less than in the acute; but it also includes all the operations on record, even those performed before the principles of antisepsis were generally acknowledged.

Among a large number of cases of laparotomy for acute intestinal obstruction, collected and analyzed by the writer,[43] there were 71 cases of acute intussusception operated upon since the year 1878, acute being understood to mean of not over three weeks' duration. The mortality of these 71 cases was seventy-six per cent., which is only a trifle lower than Braun's figures. Examining these cases a little more in detail than was done in the paper just referred to, the following table has been constructed, similar to Braun's:

Results of Laparotomy for Acute Intussusception.

	Children.		Adults.		Age unknown.		Total.		Mortality.
	Recovered.	Died.	Recovered.	Died.	Recovered.	Died.	Recovered.	Died.	
									Per cent.
I. Intussusception reduced	7	22	5	6	2	..	14	28	67
II. Intussusception not reduced:									
A. Nothing done	..	3	..	2	.	..	..	5	100
B. Resection and suture	..	3	2	7	1	..	3	10	77
C. Artificial anus made:									
1. After resection or reduction	.	4	..	..	..	..	..	4	100
2. Without resection or reduction	..	1	..	6	..	..	.	7	
Total	7	33	7	21	3	..	17	54	76

From this table it appears that out of 42 cases in which the intussusception could be reduced 28 died, giving a mortality of sixty-seven per cent.—among the children seventy-six per cent.; among the adults fifty-four per cent. In 13 cases in which the intussusception could not be reduced, and in which it was resected, and the bowel united by suture, only 3 recovered, all adults. Of the other 16 cases in which the operation was abandoned, or an artificial anus was made, all died. These figures would indicate that there is almost no hope of recovery when laparotomy has been performed, unless the intussusception can be reduced, but we have already shown that this fact need not entirely contraindicate the performance of enterostomy if it is not preceded by a full laparotomy. The age of the patient has a very important bearing upon the prognosis as affected by operation, for while only seventy-five per cent. of all the adults died, eighty-three per cent. of the children were lost. Among the cases in which reduction was possible were 22 children under one year old, and of these only 5 recovered.

But if we examine the causes of death in these cases, a satisfactory explanation of their heavy mortality is discovered in the poor condition of the patients when the operation was performed. Out of the 54 fatal cases 28 were in very poor condition at the time of operation (in fact, 2 are described as moribund); 9 cases died of peritonitis, gangrene of the gut, or other complications due to delay in resorting to laparotomy; and in 3 cases the cause of obstruction could not be remedied. Against these we have to set only 5 cases of death from shock, 6 cases of sepsis not due to gangrene of the gut, and 3 cases in which the cause of death remained undetermined—a total of 14 which can be said to have died from the operation.

It would appear as if the percentage of mortality ought to be very much less than it is if cases were taken in hand early, and it is impossible to exaggerate the dangers of delay. A very early operation would be feasible, if, as soon as a proper systematic trial had shown that injections were useless, laparotomy were performed at once. If a tumor could be felt in the abdomen beforehand, indicating exactly where the incision could be best made, and preventing loss of time in searching for it, if adhesions had not been formed, and if the operator were skilful enough to complete the operation in the shortest possible time, the mortality need not be very high even in children. The great danger of prolonged operations is shown in the high mortality of resection and suture when attempted in these cases.

As bearing upon the possibility of cure by laparotomy we may mention in this connection the rare case reported by Kleberg.[44] In a man, forty years of age, operated upon for strangulated hernia, a double intussusception of the colon was found in the sac, which was reduced after some difficulty when the incision had been prolonged upward, and the patient made a perfect recovery.

The technique of laparotomy for intussusception may be described in a few words. The rules of cleanliness and antisepsis must be fully observed. The incision should be made in the median line, unless the tumor is small and immovably fixed at one side of the abdomen, when it may be made over the tumor. The invaginated bowel, which may be brought outside of the abdomen if necessary, is reduced by making traction upon the entering layer of the intussusceptum from above, and at the same time squeezing it out from below with the other hand. If the intussusception is situated in the large intestine, the reduction can be greatly assisted by the simultaneous use of the injection given in the way just described. Any rents which are made in the intestinal wall by the manipulations must be closed at once with Lembert sutures. If reduction is impossible, the implicated bowel must be cut away between two ligatures and both ends secured in the abdominal wound, either by sutures, as in forming the ordinary artificial anus, or, if the condition of the patient is very bad, simply by a clamp—to be kept in place for from twenty-four to forty-eight hours. If the bowel is greatly distended above the intussusception, the contents should be allowed to escape before the ends are secured in the wound, turning the patient upon his side, and covering the wound with cloths or sponges. Everything must be arranged beforehand, so that no time shall be lost, and the whole operation must be carried out as rapidly as possible. For this reason it will not be advisable to attempt the tedious operation of suturing the divided ends of the bowel when resection has been necessary, except in chronic cases, in which the patients are in fairly good condition, and the cases resemble resection of the bowel for a neoplasm. The anaesthesia should be as light as possible, and therefore chloroform will frequently be the best anaesthetic to employ, as it can be suspended during the manipulations within the abdomen, which are painless, and administered again while the abdominal wound is being closed.

Summary of Treatment.—When the diagnosis of intussusception has been made in an acute case of less than forty-eight hours' duration, and without severe shock, morphine should be given at once, but in small doses, especially in children, for if the intussusception should yield readily to treatment, opium-poisoning might follow. Injections should be begun immediately, according to the method recommended above, using an anæsthetic, putting the patient in Sims' lateral position, and employing continue massage of the tumor. If the intussusception is not reduced after a careful trial, lasting half an hour at least, gradually increasing the pressure to the limit of a column of water fourteen feet high for a child, and somewhat more for an adult, all attempts should be discontinued, and consent obtained for a laparotomy in case a second trial should fail. Everything being prepared for operation, and the patient meanwhile having been carefully stimulated, the anæsthetic should be administered again after twelve or twenty-four hours, and another thorough trial of the injection made. Not until this attempt has failed should the operation be performed; but when its failure is evident, the laparotomy should at once be undertaken without interrupting the anæsthesia.

If the case is of longer duration, or if there are severe signs indicating that the strangulation is extreme, laparotomy should be performed after a single thorough trial of the injection, in order to avoid the second administration of the anæsthetic. If the duration of the case is more than three days, unless the symptoms are very mild, the injection should not be employed at all, but laparotomy should be performed at once, on account of the liability to rupture of the gut, for it is then probably weakened by the strangulation. The injection must not be attempted when the passages are fetid and contain a great deal of blood, for these are tolerably certain signs of strangulation, no matter how short a time the symptoms have lasted. If in such a case the patient is already in collapse, it will be a delicate question to decide between laparotomy and enterostomy. The latter should be given the preference if there is any fecal accumulation behind the constricted point, or if there is great tympanites; otherwise the former; and in any case the anæsthetic must be given with the greatest care. In some cases it may even be possible to operate without a general anæsthetic, by the local use of cocaine. When peritonitis has developed, laparotomy has become a necessity, to allow of cleansing the abdominal cavity; for if enterostomy is done, openings for drainage of the peritoneal cavity could not be made without danger of infecting them from the artificial anus. We have already seen that when the diagnosis depends upon the symptoms alone, and no tumor can be felt in the abdomen, injections must not be attempted; but if the patient's condition will permit it, an exploratory laparotomy should be made at once, otherwise an enterostomy will have to be performed.

LITERATURE.

[illegible]

[illegible]

[illegible]

JOINTS, CHRONIC DISEASES OF. PATHOLOGY.—Chronic joint diseases may be grouped pathologically under the heads of

I. Diseases affecting the synovial membrane.
II. Diseases affecting the cartilage.
III. Diseases affecting the bone.
IV. Diseases affecting primarily the periarticular structures.

I. DISEASES AFFECTING THE SYNOVIAL MEMBRANE.—Chronic inflammation of the synovial membrane is either a continuation of the inflammatory process described under acute synovitis (Synovitis, Acute, in Volume VI.), or it may be primarily insidious and chronic. After persisting it is characterized by thickening of the synovial membrane, an increased secretion, and retrograde metamorphosis of the connective tissue. This metamorphosis may develop granulation tissue and attack the cartilage and bone in a degenerative and destructive process, or it may terminate in an alteration and chemical change of all the tissues, which will be described under the head of chronic rheumatic arthritis; or the process may be chiefly limited to the synovial membrane.

FIG. [illegible].—Serous Synovitis of the Knee. Side view. [illegible]

(a) *Chronic Serous Synovitis* (Dropsy of the Joint, Hydrarthrosis, Hydarthrosis, Hydrops articulorum chronicus).—The pathological appearances of chronic synovitis vary much, but an increased amount of fluid is always present. Certain cases show no pathological changes beyond this increase of fluid for a long time, and these are the cases which have given rise to the names hydrops, hydrarthrosis, etc. These cases were at first thought to be dropsical and non-inflammatory, like hydrocele, but such a view is sparingly held now. Nélaton and Dupuytren may be mentioned among those who believe it. On the other hand we have Bonnet, Broca, Billroth, Volkmann, Cornil and Ranvier, and Marsh placing it among inflammatory affections. The contained fluid resembles that of hydrocele in color and consistency, but it contains mucus, and also more albumen than does the fluid of ordinary dropsy. Femoral aneurism and other obstructions to the leg circulation do not cause joint distention, even in extreme œdema, and even in the cases of primary hydrops articulorum (which are not so common as those where it is secondary to acute affections) the view is now that it is an inflammation of low grade with slight tissue change. The commonest phase of chronic serous synovitis is when it succeeds the primary acute form, and here the pathological change is at first slight and only shows a moderate increase of vascularity, and a little tendency to thickening of the membrane, which soon begins to look boggy from the continued soaking. The fluid may be brown from blood originally effused. It is not uncommon to find in these joints a small fibrinous or fibrous coagulum, when the condition is left over from an acute synovitis, and to this Barwell attaches immense importance in the production of the synovitis by irritation. These two classes, where there is little or no pathological change, may then be dismissed, and we come to the cases where pathological appearances are marked.

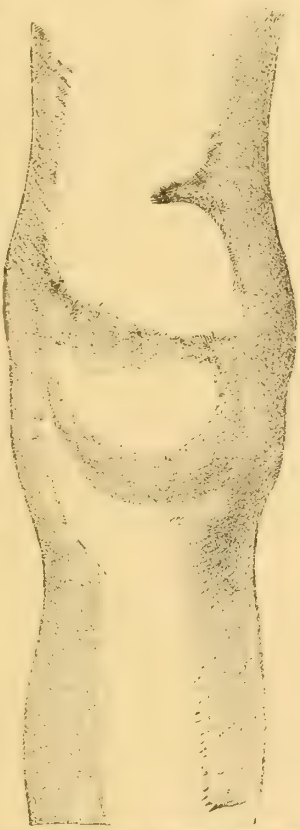

Fig. 4913. Chronic Serous Synovitis of the Knee. Front view. (Schreiber.)

The change coming next after increased vascularity and thickening of the synovial membrane is an hypertrophy of the synovial fringes. This varies from a slight hyperplasia to a condition where fibrous tissue-change has set in, and solidified them into a multitude of small fibrous polypi, so that the synovial membrane is fairly shaggy with them. In other cases they are translucent and seem to be, as they often are, fat-globules enclosed in a delicate fibrous capsule. Meantime the subsynovial tissue has hypertrophied and thickened, to even an inch in some cases, and if the fluid has been long in the joint the synovial membrane and the parts below it look light yellow, pulpy, and boggy. If the effusion has been extreme the capsule has either become enormously thickened or has given way and become much distended. If so, the lateral and internal ligaments, weakened by the continual tension and soaked by the contained fluid, have also stretched, and lateral motion may be found in the knee-joint, even to the extent of 60°.* When thickening of the capsule has predominated, cartilaginous and even bony plates may be found in the tissue. The synovial membrane in certain cases begins to encroach upon the cartilage. Normally, it runs into the cartilaginous border for two or three millimetres, but now the hypertrophied membrane sends out processes which creep in still further, as pannus does on the cornea. These cases Hueter calls synovitis hyperplastica pannosa. It is simply an extension of the process that we have considered above. It may go on to the formation of granulation tissue, but it is not likely that it will. Purulent cases generally follow another type, as we shall see. There is also an increase in the spaces between the cells in the subsynovial tissue, and a thickening and soaking of the peri-articular structures. Then come the secondary changes of the cartilage, fatty degeneration of the cartilage cells, fibrillation of that structure, and disintegration. The moment that the bone is bare, the work of condensing the tissue begins, and eburnation and enlargement of the ends of the bones result.

The outcome of this kind of serous synovitis may be in absorption, in suppuration, or in a persistent condition such as we have described, with an always increasing disability of the joint, with an extreme amount of peri-articular thickening and flexibility laterally. The hydrops articulorum tuberculosus of König is a primary tuberculosis of the synovial membrane, and König accounts for its existence by the supposition that the irritation caused by the tubercules' growth is not enough to produce its ordinary manifestation in fungous granulations; oftenest it occurs in a diffuse tuberculosis of the synovial membrane, sometimes in that form of chronic synovial inflammation characterized by the enormous connective-tissue formation described above, the class of cases which Hueter calls synovitis hyperplastica tuberosa;[8] and thirdly, in some cases of fungous synovitis in children, to be described later, the effusion has more of a serous than of a purulent character. The tubercles may be found present in a synovial membrane almost unchanged by inflammation where there were no symptoms of note before death. Ordinarily, however, the membrane is thickened and succulent, and studded with tubercles even into the subsynovial tissue. The surface tends toward granulations; if these are fully developed the effusion is generally purulent rather than watery. The exudation is often fibrinous, so that coagulation products of many shapes are present in the form of loose bodies like melon-seeds, rice, etc.; and, although formerly it was held that such bodies did not occur in tuberculous affections, König and Riedel[9] now consider that the finding of these loose bodies in the hydrops of a joint or a tendon increases the likelihood that the affection is tuberculous. This tuberculosis of the synovial membrane ordinarily coexists with a tuberculosis of the neighboring bone, although there is no communication between the two, and, from their appearance, neither is secondary to the other.[10]

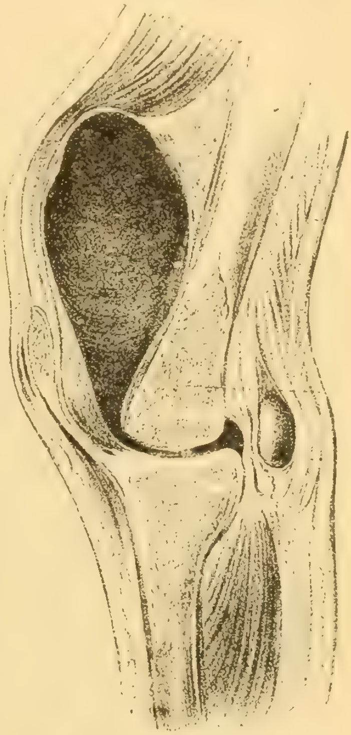

Fig. 4914.—Section of the Knee-joint in a Case of Chronic Serous Synovitis. (Schreiber.)

Arthrite Plastique Ankylosante.—There is a form of acute and subacute synovitis which has been described under the acute forms as dry synovitis. This condition is sometimes found as well in the chronic class. It represents an inflammation with a small exudation very rich in fibrine. It is apt to be associated with an infectious cause, as in gonorrhœa. The destruction of the cartilage is slight, and the ends of the bones are soldered together directly by the organized exudation. It is more common in the knee, but it may affect the hip, elbow, or shoulder (*Gaz. des Hôp.*, January 23, 1881).

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* There may, however, have been, instead, a development of cysts in connection with the joint, practically herniæ. These occur oftenest in the popliteal space in connection with the knee-joint (Baker).[7]

Chronic serous synovitis which begins slowly and not from an acute affection, and which is characterized by the slight pathological changes mentioned above, is an affection whose cause is wholly obscure. It occurs oftenest in young men; it is not associated ordinarily with the rheumatic or any other diathesis, and any attempt to assign a cause is mere speculation. It is said to be an obscure form of osteo-arthritis, but such cases are oftenest marked by the occurrence of marked hypertrophy of the synovial fringes and a tendency to connective-tissue formation. One phase of the affection is represented by the intermittent form described by Seeligmüller, in which thirteen cases are detailed. In only two cases could any constitutional cause be assigned, and these suffered from intermittent fever. The affection has no established pathology beyond this. The most common form of chronic serous synovitis, of course, is where it remains from the primary affection caused by a blow, a wound, a strain, or exposure to cold, an over-exertion, or in those obscure cases where no cause is to be assigned, which are sometimes called rheumatic on very insufficient evidence. Here the appearance is that modified appearance of the acute form described above. Next comes the gonorrhoeal variety, the result of a urethritis, the rheumatic synovitis, with its tendency to relapse and to ankylosis, and a rheumatic form without any primary stage occurring as a sequel or complication of clearly marked rheumatism. These forms are both marked by hypertrophy of the fringes and a tendency, in long-continued cases, to bone enlargement and tissue formation; and allusion is made to pure chronic rheumatism, not to rheumatic arthritis, which will be described by itself. Syphilis as a cause of this form of synovitis appears in two phases: one in the secondary stage, where it simulates the rheumatic form very closely and is ordinarily acute but sometimes chronic and persistent. At times it is markedly intermittent. If it persists it leaves the joint enlarged, indurated, and subject to subsequent attacks. And the second form is encountered in the tertiary stage, where it appears as an infiltration of the synovial membrane and subsynovial tissue of a gummatous type (Lancereaux), with a varying amount of effusion, and a tendency, if continued, to enlargement of the bones, but not especially to stiffening of the joint. Richet called it "syphilitic white swelling." The effusion may be purulent, but it is also at times serous. Chronic serous synovitis occurring in hereditary syphilis is often secondary to bone or cartilaginous affections, especially a bilateral painless form which attacks children from eight to fifteen years of age. It does not tend to go on to destructive changes, though primary forms are described. Gout is occasionally to be counted as the cause of primary synovial change where the deposit of urate of soda occurs first in the synovial membrane rather than in the cartilage or capsule. The synovial membrane is seen to be studded by the small chalky masses. Chronic rheumatoid arthritis is said also to affect at times the synovial membrane primarily, but these affections will be discussed under the head of primary bone affections. Lastly, gonorrhoea is to be mentioned as a more or less common cause of joint effusion of a chronic character, and in the joint fluid gonococci are to be found, ordinarily as a sequence of an acute or subacute synovitis of long-drawn-out course. The attack ordinarily occurs in the second or third week of the discharge, and obstinately continues the course of rheumatism and sometimes that of pyæmia; women are exceptionally attacked by it. The discussion of the etiology of the tuberculous affection will be postponed until the commoner forms of joint tuberculosis are considered.

(b) *Chronic Purulent Synovitis.*—Syn.: Tumor albus, White swelling, Pulpy degeneration of synovial membrane, Fungous joint disease, Fungous synovitis, Fungöse Gelenkentzündung, Synovitis hyperplastica fungosa, Tumeur blanche, Strumous arthritis or synovitis, Tuberculous synovitis, De granulirende Gelenkentzündung, Pyarthrosis, Gliedschwamm, Empyema articulorum, Osteitis granulosa, etc.

The name tumor albus was originally given by Wiseman to practically all cases of chronic joint disease characterized by swelling, and Brodie was the first to restrict its application to that class called by him "pulpy degeneration of the synovial membrane." Since that time it has stood as the name for that pathological condition, until of late years the terms strumous and tuberculous have come to be applied to it.

In appearance joints affected by chronic purulent synovitis differ but little from one type, although in degree they vary very greatly. The appearances in the earliest stage are those described under acute, serous, or purulent synovitis, or the synovitis hyperplastica pannosa of Hueter (see above). These are an increase of vascularity in the synovial membrane, some thickening and swelling of it, with perhaps an extension of it on to the cartilage, and an increase of synovial fluid, together with a perivascular infiltration. From this stage the membrane becomes velvety, the cartilages look roughened, and the synovia has been replaced by a fluid varying from turbid serum to laudable pus. It is possible to say in advance what a continuation of this condition would lead to, and the changes found in chronic purulent synovitis represent this continuance.

The striking thing noticed on opening a joint affected moderately is the amount of gelatinous material which seems to have replaced the synovial membrane and perhaps the cartilages. The process is simple: the hypertrophied and infiltrated synovial membrane takes on still greater activity, cell formation and vascular supply become very much increased, and the result is a typical but rather low grade of granulation tissue, which is yellowish or pinkish, and admirably described by the terms pulpy and gelatinous. Macroscopically it does not differ in any way from granulation tissue as found elsewhere, except that it often contains in its structure small white specks, which are visible to the naked eye, and which are the structures described by Köster (*Virch. Archiv*, Bd. 48) as tubercles. They were almost constantly found by him embedded in this tissue around the edge of the joint, and later in the disease generally through the fungous tissue. The proof of the identity of these structures is well enough established. Köster considered them true miliary tubercles (*Arch. de Phys.*, 1870, p. 220). Brissaud (*Rev. Mens. de Méd. et de Chir.*, June 10, 1879) thought that although pulpy fungus undoubtedly occurs without the presence of tubercles, there is abundant and ample proof that tubercle is the chief element. In this view, that the structures found are true tubercles, agree König (*Deutsch. Arch. f. Chir.*, 1879, xi., 317 and 338), and Friedländer and Ranke as quoted by him. Bacilli are found in a certain proportion of cases, as we shall see later. Barwell, as the chief dissenter, considers the structures primarily the results of fatty and suppurative degeneration ("Diseases of Joints," 1881, chap. v., p. 140). Sometimes mere accumulations of mucus constitute these structures. They are prone to undergo cheesy degeneration, either singly or agglomerated, as they are often found. When the granulations are fully developed they secrete, of course, a purulent fluid, and they may melt into pus very rapidly or very slowly, and in certain parts of the joint the process may be much more advanced than in other parts.

But this stage of disease in the synovial membrane will not have been reached without accompanying changes in the cartilage and bone. The cartilage becomes yellow and loses its opalescence, and if one tries to lift from it the synovial hypertrophies which have grown over on to it, they often cling to it, and if they are pulled away leave a red and eroded surface of cartilage under them. The cartilage may, however, become granular first in other places, especially where the opposing surfaces are in contact, and notably does this take place when the limb is in malposition and part of the cartilage not altogether used or it becomes tightly pressed together by the tonic muscular contraction. The pathological change which takes place in the cartilage in general, and which leads to these granulating spots, is this: a fatty degeneration of the cartilage cells, and a fibrillation of the hyaline substance, with cell infiltration and a tendency to a gradual return to embryonic connective tissue; and this change is, as we have seen, more advanced in some spots than in others, and in these spots is formed an erosion of the cartilage probably reaching to the bone. Often the degenerated cartilage is cast off into the joint in one piece or in flakes. As soon as the granulations reach the bone they attack the tissue of the epiphysis in all directions. Hyperæmia of it has already been present for some time, accompanying the inflammation, and its structure is readily destroyed by the action of the granulations. When the destructive processes are not too active, the osteophytes are depositing fresh bone and the periosteum is thickened. There is now no limit to be set to the destructive processes; the ends of the bones, softened and embedded in a mass of jelly, are crowded against each other by the muscular contraction, and a sinus probably is draining off the products of the destruction. The ligaments, infiltrated and degenerated, have given way or stretched, and dislocations, complete or partial, have probably already occurred, generally as a result of the predominance of the flexor muscles over the extensors. The formation of intra-articular abscesses and their escape to the surface through the degenerated capsule needs no explanation; a fistulous track, lined with the same gelatinous material, marks their path. Sometimes the abscess has been extra-articular, and results from the breaking down of the peri-articular cellular infiltration, which contributes so much to the enlargement of the joint. The division of the disease into stages has no pathological basis. The appearance of joints affected secondarily from a primary bone lesion does not differ from that described above.

At any period of the affection reparative processes may set in. The granulation-tissue then becomes less succulent, and the areolar tissue in it becomes more prominent and the cells less numerous. In time, fibrous tissue forms in its place, and from this may result complete or partial anchylosis, and if these fibrous bands become ossified so-called true anchylosis is the result. If the cartilages have not been extensively destroyed, or if the affection has been chiefly synovial, any degree of restoration, even complete mobility, may result.

It is not uncommon to find associated with fungous joint disease tuberculosis of the lungs, or of the meninges, or general miliary tuberculosis.

Chronic purulent synovitis is sometimes the result of an acute serous or purulent synovitis, but the tendency in healthy individuals is not to run on to this form; when this occurs it is oftenest in adults of feeble constitution and in children of the feebly resisting type described as strumous, tuberculous, and scrofulous, as we shall see later. It is ordinarily a very difficult matter to say, clinically, whether the disease is primarily synovial or osseous; formerly the tendency was to regard such diseases as synovial, but of late years the view has changed, largely in consequence of the work of Volkmann and König, until now it is considered that in the great majority of cases chronic joint disease, especially in children, begins as an osteitis. Müller[21] analyzed 232 preparations, mostly from resections, with the following result:

	Bone-origin.	Synovial origin.	Indefinite.	Total.
Knee	69	33	16	118
Hip	47	3	11	61
Elbow	42	10	1	53
Total	158	46	28	232

Age.	Bone.	Synovial.
Three to fourteen years	50	21
Fourteen to thirty years	64	18
Thirty years and upward	39	12

Of 71 other cases analyzed by König,[22] 47 were osseous, and the distribution was as follows:

	Bony.	Synovial.
Hip	8	7
Knee	17	6
Foot	11	7
Shoulder	3	1
Elbow	8	3

Volkmann,[23] as the representative of extreme German views, believes that fungous joint diseases begin usually, and in children always, as a localized osteitis limited to a spot in the epiphysis near the joint. Unhappily figures bearing on the subject are scarce.

With the discovery of tubercles in fungous joint disease came into vogue the terms tuberculous, etc., which have given rise to so much discussion. The histological identity of the structures described by Köster is well enough established by the weight of evidence. Tubercle bacilli are found in a certain proportion of the cases, and a clearly tuberculous history is present in the families of the greater proportion.

Schüller, of Greifswalde, in support of the tuberculous theory of joint inflammations, rendered guinea-pigs and dogs tuberculous by the injection into their lungs of (tuberculous) sputa from cases of phthisis, and by causing others to inhale the same material. He then wrenched and strained the knee-joint and in the greater proportion of cases a fungous synovitis, sometimes attended by suppuration, followed. The same wrenching and straining in the knees of healthy animals did not induce disease of the joint.[24] Barwell is the chief objector to the experiments, but his objections lack force altogether.[25] Hueter demonstrated[26] that tuberculous matter (phthisical sputa, etc.) injected into the joint of an animal will cause a fungous hyperplastic synovitis of the type that we have been considering, and from this focus general tuberculosis may follow; and that a piece of the granulations from a human synovitis fungosa, introduced into the anterior chamber of a rabbit's eye, caused choroid tubercle, and, later, general tuberculosis. And König (*loc. cit.*), by introducing the fungous proliferations of joint-synovitis into the general circulation of animals, caused general tuberculosis. So much for the experimentation bearing directly on the subject. The bearing of this on the etiology, as well as on the questions of heredity, trauma, and so forth, can be best discussed after the consideration of joint disease of bone origin, for the two run into each other so much that any separate consideration of their etiology is almost impossible.

II. JOINT DISEASES AFFECTING THE CARTILAGE (Syn., Chondritis, Ulceration of cartilage, Degenerations of cartilage, Fibrillation, etc.).—Cartilage is a tissue of low grade, non-vascular and sluggish in all its reactions, and it is to this that we must turn for the explanation of the extreme rarity of primary inflammatory disease of the cartilages of the joints. Surrounded on one side by synovial membrane and on the other by bone, this tissue lies in the neighborhood of far more irritable tissues than itself, which react to any trauma or constitutional irritant long before the cartilage does, and, rightly or wrongly, are to be considered as preceding and originating the changes in the cartilages.

Hyaline cartilage is a bluish-white, opalescent structure of great density which covers the ends of the bones in all diarthrodial joints. It is, as we have seen, non-vascular, and derives its nutriment from the bone and synovial membrane, which furnishes another explanation why secondary affections are so common. It consists of hyaline substance and corpuscles, which lie embedded in the former and contain one or more nuclei; they fill the spaces in the matrix. These corpuscles lie near the joint surface in layers parallel to it, but deeper, near the bone, in columns perpendicular to the cartilaginous surface, which accounts for the readiness which the cartilage shows to be chipped vertically. Externally the cartilage is attached to the bone by the perichondrium, and the internal surface lies free and moist in the joint.

Fibro-cartilage, when present, appears as something intermediate between fibrous tissue and cartilage. It appears vertebral bones—intervertebral, sternoclavicular, and [illegible] the symphyses; and, lastly, as the connecting substance in joints which are not more completely formed, as in the [illegible] joints. Histologically it consists of fibrous tissue interspersed with cartilage cells and it possesses far greater toughness and elasticity than hyaline cartilage.

(a) *Hypertrophy.*—Simple hypertrophy of cartilage, without the soft condition so often found in chronic synovitis from continued irritation, is rare in the articular cartilages except in the marginal ecchondroses which are found in the degenerative changes accompanying certain general conditions, such as rheumatoid arthritis. Such circumscribed hypertrophies occur around the margins of the surface. Sometimes they occur also in the degeneration of cartilage characterized by the deposit of urate of soda, and sometimes in connection with synovitis fungosa, or synovitis tuberculosa of Hueter. In children whose ossification has been delayed the articular cartilages may have the appearance of great thickness.

(b) *Atrophy.*—Except as the result of degenerative changes atrophy of the articular cartilages does not occur, unless it be to a very slight extent in the joints of old people, and sometimes slightly in joints subjected to great pressure.

(c) *Degenerative Changes.*—The type of degeneration in cartilage is peculiarly constant. Its phases are many but the process is essentially one. In a word, it consists of a cell-multiplication and fatty or granular degeneration of the corpuscles, and a fibrillation of the hyaline substance. Whether we have in question primary or secondary degeneration, the results of injury, or the degeneration of gout, we shall see the type clearly demonstrated. The processes are phases of one degeneration rather than separate pathological processes.

1. Inflammatory (primary).—In the overwhelming number of cases these changes are purely secondary. The existence of primary disease is denied by such men as Hueter, Barwell, etc., but there have been recorded from time to time certain cases which seem to establish the fact that primary erosion of the cartilage does occur.

The writer in "Holmes' Surgery" says: "Inflammatory alterations of the cartilages, unaccompanied by disease of any other joint tissue, may possibly take place, though cases of it are not easily met with;" and that seems a fair statement of the situation. Years ago the discussion was not as to primary disease, but as to whether inflammation was present in cartilage at all, and whether the changes found were not the result of the other tissues acting on it. The researches of Redfern, Goodsir, Virchow, and Weber[32] establish the active character of the changes well enough, and their writings give the story of the controversy. As to the existence of primary disease, Brodie reported some cases that he considered primary cartilage disease; but, looked at in the light of modern pathology, there seems but little doubt that they were cases of primary disease of bone. The same is true of a case called "acute idiopathic ulceration of cartilage," reported by Mack, where the bone "was extensively carious." Paget claims to have found erosion and ulceration of cartilage without disease of other tissues. Bauer reported a case in 1871 where there seemed little doubt that it was a case of primary cartilaginous disease of the intervertebral disks, and at autopsy the eight upper dorsal disks were found to have been destroyed, while the cervical disks had become soft and pulpy. The patient was fifteen years of age, and the disease had lasted six years; there was probably a traumatic origin. Other cases of suppurative inflammation of the intervertebral disks are recorded by Ogle, Bruns, and Chassaignac, where ulcerative changes were found in one or more of the intervertebral disks, which varied from a small perforation to complete disappearance of the disk.

The pathological process in itself is the same, of course, so far as primary disease of cartilage is concerned, as the one to be described under secondary inflammatory degeneration. Koenig reports three cases of circumscribed fungous disease of the internal meniscus in the knee-joint.

2. Inflammatory changes (secondary).—As a result of the inflammation of synovial membrane or bone, secondary inflammation of cartilage is common enough. The number of nuclei in the cells, and the number of cells in the corpuscles, multiply very fast. There is a certain amount of fatty degeneration of the cells present, and striation of the hyaline substance goes on to fibrillation, and this to local or general disintegration. The cells break from the corpuscles and infiltrate the whole cartilage; it becomes yellowish and soft. But if the process is very acute the hyaline substance is disintegrated without having time to undergo much fibrillary degeneration; the proliferation of [illegible] is the prominent part of the process. If it is slower, fibrillation is more marked. At any rate, disintegration generally comes on, and where the cartilage is gone (generally where the pressure is greatest) an ulcer with a granulating base and clean-cut edges is seen, of greater or less extent. The base of the ulcer consists of typical granulation tissue. And in this way the entire cartilage may quickly disappear, or these ulcers may go on to cicatrization and heal by the formation of a connective-tissue scar.

At other times, where an osteitis is the primary disease, the deprivation of the cartilage's nutriment causes it to die, and the whole or parts of the necrosed layer of articular cartilage may be thrown off into the joint-cavity, leaving ulcers or the whole denuded granulating end of a bone. The yellow opaque pieces of cartilage lie a long time in the joint or are disintegrated into pus.

3. Fatty degeneration.—Another phase of this same pathological process, where the fatty or granular degeneration predominates and fibrillation is slow and more stable, constitutes what is generally classed as fatty degeneration. Unlike the other, it does not cause ulcers, but the degenerated fibres are tough and resistant and attached at one end, while the other lies free in the joint-cavity, and the whole surface may be thick and pulpy, or hard and fibrous. Intermingled with the fibres are fat globules and a few leucocytes, and the cartilage corpuscles are either disintegrated or filled with fat globules. The fibres may wear away and leave the bare ends of the bone, not ulcerated and covered with pulpy granulations, but white and eburnated. Fatty degeneration of cartilage is considered to be analogous to the arcus senilis of the cornea in its etiology and pathology.

4. Fibrillary degeneration.—Still a third phase of this same process constitutes what is called fibrillary degeneration. Fatty degeneration and cell multiplication in the cartilage corpuscles assume a subordinate place, and fibrillation of the hyaline substance becomes the all-important part of the degeneration. The fibres are well marked, and where pressure occurs they are worn away evenly or unevenly, and where they are worn away [illegible] white, thickened, ivory-like bone, and calcareous degeneration occurs in the patches of degenerated cartilage. It is "the ossification of cartilage." Around the edges the cartilage is covered by the synovial membrane, probably hypertrophied, and here cell-formation and fibrillation begin as well as elsewhere; but the cells cannot escape, having no free cartilaginous surface, and they are retained and become active in the formation of cartilage, and the marginal ecchondroses of which we have spoken are formed. In time calcareous deposits occur in these as well. Sometimes they break off, and form one kind of the "loose bodies" in the joint.

The deposition of urate of soda in the hyaline substance may perhaps be called the gouty degeneration. It is not a different process from the others—cell-multiplication and fibrillation go on as before; simply this urate deposit is superadded in the cartilage, where it is seen sometimes (in very acute cases) as a single superficial layer, then later in white patches which are larger below the surface, where on more careful examination it is seen to have left the corpuscles free and to have settled in the hyaline substance around the corpuscles. Later it invades them also, and disintegration goes on. A simultaneous deposit of urate of soda occurs in ligaments, bones, and the periarticular structures.

The etiology of primary inflammation of cartilage is, of course, extremely obscure. In some of the cases reported it was traumatic in origin, in others no cause was assignable. Some patients were old, others young; in fact, there seems nothing to indicate in which direction the cause lies.

The etiology of secondary inflammation is to be sought in the cause of the primary affection—trauma, tuberculosis, a penetrating wound of the joint, or whatever may be at the root of the synovitis or osteitis. Reyher described a change in the cartilage due to disuse of the joint characterized by a slow inflammatory process, which he produced by immobilizing for weeks the limbs of some dogs.

Fatty degeneration of cartilage is an ill-defined process accompanying the later stages of chronic synovitis, occurring in old age and as a subordinate process in rheumatoid arthritis. But here fibrillary degeneration is the characteristic form, along with the increased bone-formation, but fibrillary degeneration pure and simple is the expression of the general morbid condition known as rheumatoid arthritis.

Gouty degeneration expresses its etiology in its name. As to the deposition of soda urate there are two theories in vogue—one, that the uric acid in the blood is deposited as soda urate in the cartilages, the other, that the soda urate is formed in the cartilages itself and remains there because there are no blood-vessels to carry it away. The latter theory gets support, says Mr. Marsh, from the fact that gouty deposits outside of the joints are found in non-vascular structures like the fasciæ and tendons. It occurs more in the central than in the peripheral parts of the cartilage.

(*d*) *Loose Bodies in the Joints* (Syn.: Loose cartilages, Mures articulorum, Corpora libera articulorum, Joint mice, Floating or movable bodies in joints, etc.).—Loose bodies in the joints are classified according to their structure. There are three classes: 1, Fibromatous; 2, lipomatous; and, 3, chondromatous. (Hueter.) In size they vary from that of a small pea to that of a horse-chestnut or larger, and they are of all shapes. The smaller ones are oftenest shaped like melon-seeds or irregularly round, while the larger ones are more regularly round, concavo-convex, or spherical. Sometimes they are faceted and crowded together like the carpal bones, and sometimes they are mulberry-shaped or pyriform. In one joint they may appear singly or in great numbers, and they may vary a great deal in size in the same joint. Mr. T. Smith removed recently over four hundred from one knee-joint.[11] The knee-joint is by far the most apt to be affected, and Barwell estimates that nine-tenths of all cases occur in that joint.[28] Next in frequency comes the elbow,[40] and all of the larger joints are liable to contain these bodies, even the temporo-maxillary articulation, it is said, having been once affected. In external appearance they are whitish or yellowish, and vary from a soft consistency to a bony hardness. On section they show either a plain fibrous structure, or a fibrous sheath enclosing a mass of fat, or even the structure of hyaline or fibro-cartilage (ordinarily without corpuscles), or that of bone tissue, oftenest without Haversian canals. Not infrequently they present a combination of two of these forms.

Their chief interest lies in the method of their formation. A matter of much importance in their etiology is the fact that their presence is very often associated with rheumatoid arthritis. They are produced in several ways: 1. In the form of chronic serous synovitis, described as synovitis hyperplastica tuberosa, the hypertrophied tufts of synovial membrane often become pedunculated by so slight a stalk that it breaks and the enlarged tuft is set free in the joint-cavity; or, again, the cartilage cells occasionally found in these tufts take on activity and form a mass of fibro-cartilage, which is detached in the same way; or, rarely, an enchondroma develops from the cartilage itself and becomes detached. 2. Osteophytes grow into the joint from the periosteum, or calcareous or bony plates form in the joint capsule or cartilage (and exceptionally in the synovial tufts) in the condition of rheumatoid arthritis, and these bony masses are broken off or the nodules in the capsule are detached and form an important class of free bodies. 3. Sometimes the free body seems to be only the remains of a blood-clot or the deposition from a synovitis particularly rich in fibrine. 4. And lastly, there is certainly a class of traumatic cases which have been much discussed. Formerly it was held that these free bodies (of the chondromatous class) were the result of the direct forcible tearing off of pieces of cartilage by wrenches or strains or blows, and Hueter supports that view,[41] as does also Virchow.[42] The more modern view is represented by König, who does not deny the possibility of this tearing off of bits of cartilage, but he insists upon its rarity and shows the great force necessary to detach them in this way. Rather, he says, consider that these pieces are so bruised and injured by the trauma that their necrosis follows, and then a spontaneous osteochondritis dessicans which leads to their detachment and sets them free in the joint.

Further cases in which the traumatic origin of these chondromatous free bodies is beyond question are given by Mr. Marsh,[43] notably one where, three weeks after a wrench to the knee, a free body was removed by Mr. Simon, which Mr. Shattock pronounced to be a piece of the articular surface.[44]

There seems reason to believe that, despite the lack of blood-vessels, these bodies continue to be nourished, after being set free in the joint; not only does ossification take place after they are freed, but the case of Recklinghausen[45] would seem to show that growth is also possible.

III. Joint Affections Beginning in Bone.—The pathological appearances of primarily osseous joint-disease will be considered, so far as possible, under two heads—(*a*) degenerative, and (*b*) formative osteitis.

(*a*) *Degenerative Osteitis.*—The type can be described in a very few words—hyperæmia of the vessels, infiltration from the distended capillaries, and the formation of large spaces (lacunæ of Howship), with absorption of the trabeculæ; fatty degeneration of the bone-cells, and their final replacement by embryonic tissue. The mechanism is, then, at hand for any amount of destruction. The greater part of degenerative osteitis of the ends of the long bones follows one type, which is now called tubercular. It is not here assumed that this term is correct; the pathological appearances will be described, and the evidence for and against the tubercular character of the affection will be presented.

This type of disease presents itself ordinarily in the spongy tissue of the epiphyses of the long bones, oftenest near the line of junction with the shaft, sometimes very close to the articular cartilage, however, and sometimes in the periosteum. It presents itself under two forms (1), commonly as a single focus, or multiple foci of diseased tissue (encysted tubercle of Nélaton), and (2) rarely as a simultaneous tuberculous infiltration of the whole epiphysis (infiltrated tubercle of Nélaton). It is impossible to identify these appearances with all the various names by which they are known; some of the prominent are given. And first, the term caries must be considered, which is to-day only a loose term for all sorts of bone disintegration, used especially by surgeons. Oftenest it means this form of bone disease under consideration. It is a term which will be avoided in this article. Ziegler gives the following synonyms for tuberculous osteitis: "Caries mollis sive fungosa, scrofulöse caries, tuberculöse caries, Knochen-nekrose, Knochen-abscess, fungose arthritis, fungus articuli, Gliedsschwamm, scrofulöse Gelenkentzündung, Gelenk-caries, arthrocase, tumor albus, caries sicca," etc.[20] Of French terms may be mentioned osteopériostite tuberculeuse chronique, tuberculose articulaire, etc., not to mention such fine distinctions as tubercule tardif à évolution rapide and ostéite tuberculeuse aiguë.[46] In English one identifies, as synonyms, scrofulous joint-disease, tuberculosis of bone and joints, spina ventosa, and the greater proportion of cases of chronic articular osteitis (Gibney,[47] *e.g.*, considering no other form of this than the tubercular).

1. In the formation of single and multiple foci of disease the first change noticeable to the naked eye is the

appearance in an already hyperæmic spot of spongy tissue, of a small, grayish, yellow translucent spot, as small as can be seen, perhaps, which grows more gray and increases in size; and around it a zone of hyperæmic tissue develops, and the neighboring bone becomes a little boggy-looking from an excess of fluid transuded. There is no affection of the synovial membrane; it is purely a localized osteitis, or, more correctly, osteomyelitis. The diseased spot grows larger and begins to break in spots, yellowish, and to show a tendency to cheesy degeneration in the centre, and later in the history of the affection cavities will be found, varying in size from a pea to a hazel-nut, filled with a putty-like substance, like the cheesy material found elsewhere in the body, except that here it contains spicules of bone from the trabeculæ, and in the larger foci pieces of dead bone of considerable size. Later in the history of the affection the tuberculous nodule ordinarily breaks down into pus, and it is said that absorption at this stage has occurred, leaving nothing but a cavity filled with limpid serum.* Oftener than not the original focus is surrounded by smaller nodules which aid in its extension; but the chief work is done, as we shall see, by the erosive action of the granulations (rarefying osteitis). Sometimes a sequestrum of considerable size may be found in these cavities: the granulations have cut off the source of nourishment from a certain area of bone, and it has died and is loosened from the sounder parts and lies loose in the cheesy or liquid pus; or a piece of bone too large to be contained in the cavity may die and be loosened as a wedge-shaped piece at the end of the tibia. Ordinarily these larger pieces are of a wedge-shape, with the base at the end of the bone, the ordinary shape of an infarction. Even the whole epiphysis of the femur may be detached. The cavity, it should be noted, is sometimes sharply marked and lined by more or less of a pyogenic membrane; at first it is soft and gelatinous, later it becomes more resistant and tougher. If the retrogressive metamorphoses take place, the surrounding tissue takes on a sclerosis, a sort of scar formation.

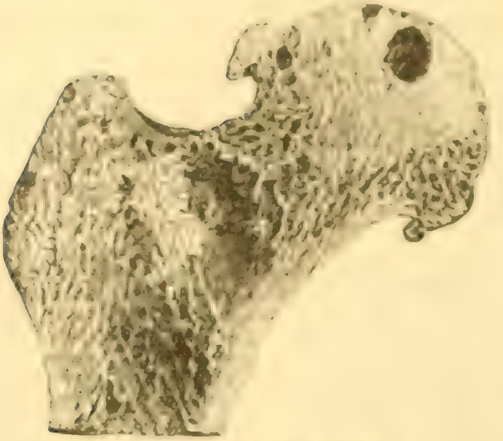
Fig. 4415.—Abscess of the Epiphysis.

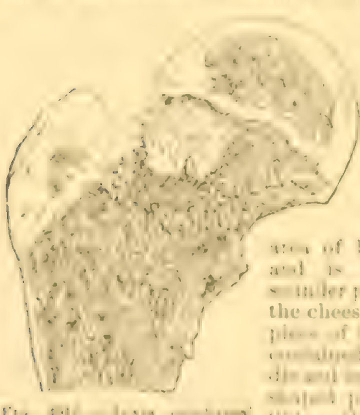
Fig. 4416.—Large Sequestrum [illegible]

From this stage of the process any one of three courses is possible: the diseased focus may be absorbed and sequestrated; it may extend to the periphery of the bone, and break through the periosteum and empty itself there; or, lastly, and probably most commonly, it may extend to the joint and infect that.

2. The second form—simultaneous tuberculous infiltration of a whole epiphysis—is much rarer than the focal form above considered. It is characterized by the deposit in the meshes of the spongy tissue of a gray substance like lymph tissue, which is in gross appearance like the focal lesion just mentioned, without limit or boundary. In spots are to be seen yellowish pus collections which ultimately extend, and the whole affected area assumes the aspect of a true purulent osteomyelitis. It is this stage that is ordinarily found on section. The true tuberculous infiltration presents a different appearance from the subsequent purulent infiltration, which is characterized by a dull yellow surface and an absence of blood-vessels.

Microscopic examination of the contents of the degenerated spots of either affection shows a typical granulating tuberculosis. As a rule, when cheesy degeneration has not proceeded too far, one finds within the low-grade vascular granulation tissue numerous and characteristic tubercles, with epithelioid and giant cells.** With the increase of cheesy degeneration the typical tuberculous becomes more and more obscure. Even in the cases where large sequestra form in the ends of the bones without any evident tuberculous foci, one can ordinarily find, without trouble, tubercles in the granulation layer between the sequestrum and sound bone.

The tubercles are found in a dense plasma composed of a great quantity of amorphous matter, fatty and calcareous granules and leucocytes. Outside of this one sees enlarged bone spaces, atrophy of the trabeculæ, fatty degenerated bone-tissue, surrounding embryonal tissue as compared the seat of disease. In short, the changes are those which we have seen accompanying long-continued hyperæmia in bone, and which constitute the rarefying osteitis of French writers.

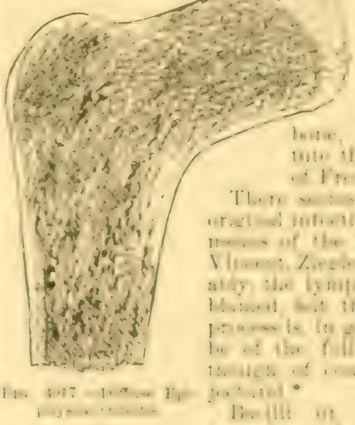
Fig. 4417.—Diffuse Epiphyseal Osteitis.

There seems little doubt that the original infection comes oftenest by means of the blood-vessels (König, Virchow, Ziegler). Sometimes, probably, the lymph-channels are to be blamed, but the beginning of the process is in general understood to be of the following character, although of course it is partly conjectural.*

Bacilli or micrococci become lodged up in the capillary of a Haversian canal, cut off the blood-supply, and start up in the neighborhood an endarteritis of the type known as tubercular, an infiltration of leucocytes, the formation of a lumen of Howship, and the formation and continual increase of embryonal or granulation tissue. The trabeculæ grow thin and the bone-cells undergo fatty degeneration and disintegrate, while their place is taken by the embryonal tissue-cells, which continually extend and soak away the bone substance. Hence the formation and extension of the diseased focus. Sometimes, however, the seat of disease is surrounded by a condensing rather than a rarefying osteitis. Kiener and Poulet make three stages of the process, which perhaps will explain the sequence a little more fully: (1) fibrous or embryonal transformation of the marrow; (2) appearance of the tubercles with condensing and rarefying osteitis; (3) caseation of the marrow and eventual necrosis of the trabeculæ. As to the absorption of a tuberculous focus the spot of diseased tissue becomes cheesy and the granulation-wall surrounding it changes from its erosive to a formative action, having a tendency to send processes into the cheesy mass, which processes become fibrous and ultimately bony tissue, but the tendency is to incomplete scarring. A bit of tuberculosis granulation remains behind perhaps for years, and explains in a measure the tendency to late relapses in this class of disease. The entire absorption of large sequestra is very doubtful (König).

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* Kiener and Poulet (Arch. de Phys., 1883) have demonstrated that the seat of the tuberculosis [illegible] the beginning of the disease [illegible]

Primarily or secondarily, the periosteum is quite sure to be affected. If, primarily, a tuberculous focus is seen under the periosteum and the bone destruction around it is superficial, it is called a peripheral caries; but if the periosteal focus is secondary, it communicates with the original point of disease in the marrow. The periosteal foci, like the others, become cheesy or melt down to form abscesses. But even before the tubercular focus is deposited in the periosteum, increased periosteal activity begins; sometimes with absorption of the deposited inner layers, as in spina ventosa, where the whole circumference increases, yet the marrow cavity increases still more all the time; while in other cases osteosclerosis (a formative osteitis) takes up the whole bone.

With Koch's discovery of the bacillus of tubercle in 1882, there came in a new criterion in the determination of whether or no certain microscopical appearances really represented tuberculosis. The question of the importance of inoculation results belongs rather to the domain of etiology, whereas the presence or absence of bacilli is determined by a simple microscopical examination. They are found lying oftenest in the giant-cells, sometimes in the other cells; they are few in number, and hard to find. Koch[50] found them in two cases out of four in fungous joint disease. Since then various observers have found them in a varying proportion of all cases examined. Schuchardt and Krause examined all cases of "fungous and scrofulous joint disease" coming to Volkmann's clinic for some weeks, some forty cases altogether, in all of which they found the bacilli of tuberculosis; but they were very few in number, and very hard to find. A modification of Ehrlich's method was used, the details of which can be found in the article Bacteria. In one cold abscess twenty sections were required to find two bacilli. Kanzler,[51] in 15 cases of bones and joints examined, found bacilli in only 8. Müller[52] examined some 39 cases, using pus for the most part, and in a few cases he was unable to find the bacilli, although he would examine most carefully perhaps twenty preparations of each. He believes, on the strength of this, that it is possible to have tuberculous joint disease without the presence of bacilli. Castro Soffia,[53] in a great number of clinical cases of bone tuberculosis examined for bacilli, was always able to find them. Reuben,[54] in 5 cases of spina ventosa, otherwise free from tuberculous disease, found the bacilli in all cases, looking for them in the granulations, and, moreover, inoculation was successful. In general, the results of later years are more positive than the earlier results, probably from perfection of methods. The evidence presented seems to justify the conclusion that in most cases of chronic joint disease of the character just described, tubercle bacilli are present, but that the examination for them is difficult; and, moreover, that they are present in smaller numbers at the late stage, when most examinations are made; probably in the stage of invasion an examination of the tissues would show many more.

The results of inoculation experiments, as establishing the identity of bone tuberculosis, and that of the lungs, for instance, will be considered under the etiology.

Secondary Infection of the Joint.—With regard to the ultimate infection of the joint from the epiphyseal focus, the process is easily understood. The seat of the disease is ordinarily not far from the cartilage when it is beginning, as we have seen; it excites no joint inflammation, but when it reaches a certain stage, even before it breaks into the joint, inflammatory reaction in the joint begins. This is perfectly well established; take one of Lannelongue's early autopsies:[55] *e.g.*, in a case of early hip disease, a focus the size of a pea was found in the epiphysis, 2 mm. from the cartilage; it was caseous and did not in any way communicate with the joint, yet although there was no effusion the capsule was thickened, the synovial membrane in parts thickened and fungous, and the round ligament already vascular and fungous. The cartilage in certain parts was thinner and losing its elasticity. One other of his autopsies and the early resections of Volkmann[56] show the same point, even more advanced joint changes being found than Lannelongue's autopsies showed, viz., increased synovial fluid, swelling of periarticular structures, and thick and red synovial membrane.

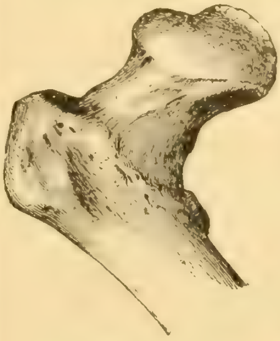
FIG. 4918.

It should be remembered that opportunities to study the early stages of joint affections are very rare, but it would seem then as if often the joint were involved and inflamed in the first place by contiguity rather than by direct infection, and, by its inflammation and softening, the cartilage over the diseased spot of bone was rendered the more ready for the direct invasion of the pus and caseous material from the primary focus. The destruction now spreads in the direction of least resistance, ordinarily in the direction of the joint surface, the cartilage being already thinned and degenerated, and the synovial membrane soft and fungous with the articular lamella perforated; the cartilage at last gives way, and the original focus cavity communicates with the joint cavity.

"The danger to the joint begins with the softening of the cheesy masses" (Volkmann). When once the pus has broken through the softened and degenerated cartilage and has reached the synovial membrane, a purulent synovitis is at once started up which speedily assumes a fungous and destructive character, and a "panarthritis" has begun. Thickening of the capsule, infiltration of the periarticular tissues, and thickening of the ends of the bones follow quickly, and abscess formation and all the other complications are ready to follow. It matters little now whether the process began in the synovial membrane or the bone; this stage being the same in its clinical appearances and its capability for evil. Any amount of destruction is of course easily possible—erosion of the articular surfaces, spontaneous subluxations and luxations of the joints, cold abscesses of any extent reaching the surface and continuing to discharge by many sinuses; and, worst of all, from the local disease comes the dissemination of general tuberculosis, or tubercular meningitis, or phthisis.

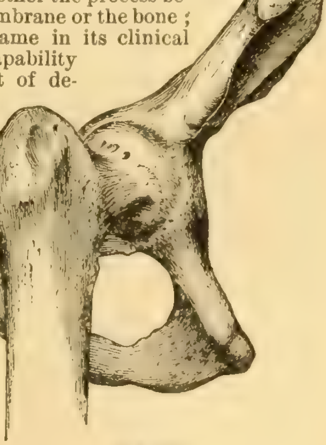
FIG. 4919.

Sometimes, however, the focus is so situated that the line of least resistance takes it to another part of the bone surface away from the joint; Volkmann showed clearly that this was no very uncommon occurrence. As it reaches the periosteum the latter thickens and inflames, and finally softening, allows the pus from the original focus to pass into the periarticular structures, there to form an abscess which must be evacuated externally or break. Sometimes this ends the disease, the granulation tissue becomes fibrous and then osseous, and the disease is over.

Gummatous Synovitis.—There is another and much less common form of degenerative arthritis which affects the subjects of tertiary and hereditary syphilis. This is characterized by the formation of gummata in the spongy tissue of the epiphyses, or more commonly in the periosteum; but a much more common location still is in the shaft of the bone. It is not common for the epiphyses to be affected before the synovial membrane, but it does occur, although synovitis is much more common from this cause. On section the bone shows, oftenest in the periphery, a yellowish-gray focus of disease, in appearance strikingly like the early stage of focal tuberculosis. But from this latter it may be distinguished, according to Schüller, by the absence of any surrounding hyperæmia or infiltration, which, he says, always goes with tuberculous disease. Often, of course, these gummata exist along with much synovitis of a characteristic type, and a much thickened and diseased periosteum. Gummata in the periosteum appear as elastic swellings, rich in fluid, poor in cell-elements; later they degenerate to stuff like pus and, by fatty degeneration and absorption, a cheese-like substance and scar tissue; and finally only a thickening remains.

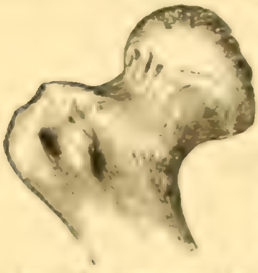

FIG. 4[illegible].—Destructive Epiphyseal Osteochondritis.

Secondarily to these periosteal and bone lesions come the capsule and synovial thickening, and the cartilage degenerations noted above.

Osteochondritis.—One special form of syphilitic disease deserves mention, viz., syphilitic osteochondritis with accompanying epiphyseal periostitis and perichondritis as Ziegler calls it. Before the joint is infected, one finds a circular swelling around the epiphysis; this is a periostitis with much spongy tissue under the periosteum, which later affects the joint perhaps with a destructive purulent synovitis,[67] or a subacute or chronic synovitis with much effusion and thickening.[68] Occasionally the inflammatory process is of such a character that the epiphysis is loosened from the shaft by the destructive process.

To make the diagnosis between syphilis and tuberculosis from the appearance of the bone alone might occasionally be difficult, but aided by clinical characteristics there would not often be much difficulty.

The microscopical structure of the focus of disease shows a typical gummatous structure.

Acute Infectious Osteomyelitis.—Acute infectious osteomyelitis sometimes affects the epiphyses of the long bones and in that way secondarily infects the joints. It begins in the bone-marrow or the periosteum. The marrow becomes hyperæmic, the periosteum infiltrated and thickened, and in both are seen beginning foci of pus, and sometimes hemorrhages in their tissue; soon pus formation obscures everything, and the bone fairly melts away; large collections of pus may form between bone and periosteum. Ordinarily this affects the shafts of bones, but sometimes the epiphysis, and secondarily the joint, become infected when the foci of disease are near the joint; like the tuberculous foci, they tend to infect it.

Cocci are constantly found,[69] oftenest staphylococcus pyogenes aureus and albus. Extensive necrosis results.

Simple or Traumatic Ostitis [illegible] affecting the joints is very different. In the traumatic form one finds blood effused and beginning inflammatory processes of the kind described above as typical. The periosteum is infiltrated and the bone-marrow filled with a fluid cellular exudation. Then it depends upon circumstances whether absorption will take place, or whether pus formation will begin and the trabeculæ will be absorbed and the bone broken down, or whether the whole affair will take on the tuberculous type and run the course of that affection. If no infection comes, wounds, tears of the joint capsule, fractures, etc., result in only a series of fractures or bloody effusion into bone, joint, and capsule; but where the bone is opened, so that infection may take place, destruction and necrosis are only too apt to result.

Formative Osteitis (*Arthritis Deformans*).—The chief kind of formative osteitis affecting the joints to any degree is the form known by the following names: Rheumatic gout, chronic rheumatic arthritis, arthritis sicca, arthritis deformans, osteoarthritis, senility of the joints, rheumatoid arthritis, nodular rheumatism, dry arthritis, proliferating arthritis, malum senile, chronic articular rheumatism. The name arthritis deformans will be adopted here, inasmuch as it describes the condition and involves no etiological theory.

The condition has been asserted to have its origin in the bone,[?] the synovial membrane (R. Adams and Smith, Volkmann, Cruveilhier), and the cartilage (Marsh, Ord, R. Smith, Cornil and Ranvier).

The weight of modern authority places its ordinary origin in the cartilage, or the cartilage and synovial membrane. There is a thickening of the synovial membrane, a hypertrophy of the fringes, and finally the development of the shaggy surface already spoken of. The changes in the cartilage are of the usual type of cartilage inflammation, only more severe. The hyaline substance becomes fibrillated, and where there is pressure it is worn away in small patches or large surfaces, exposing the bony lamella, which speedily becomes polished and ivory-like from the friction. The same process of cartilage degeneration taking place at the periphery results differently. There is freedom from pressure enough to wear away the degenerated substance, and the covering of synovial membrane retains the proliferated corpuscles, cells which remain and, taking on a formative activity, make the marginal hypertrophies or ecchondroses already mentioned.

Sometimes these perforate the synovial membrane and become intra-articular, and often break off to form loose bodies; at other times they grow laterally, and do not encroach upon the joint. Inasmuch as these ultimately ossify, an explanation of the extreme changes in the shape of the ends of the bones is afforded. The chief changes are to be found in the bones. The destruction of the overlying cartilage leads to the exposure to friction of the articular lamella and the consequent irritation of the articular ends of the bones. This irritation is followed by hyperæmia and a consequent slight degree of rarefying osteitis, which is the necessary first stage of a formative osteitis; but after the enlargement of the Haversian canals and the degeneration of the bone-cells, a formative activity springs up in the periosteum, and in the endosteum covering every one of the cancellar walls, and a compact "eburnated" layer is quickly made, which covers the exposed end, under which layer a formative activity is going on, while the polished surface is always being worn away; and to this constant wearing away is due the "worm-eaten" appearance so generally spoken of, which is due to the exposing of the end of the Haversian canals. But while pressure and friction are wearing away the centre of the articular ends of the bones, the margins where pressure and friction are slight are rapidly proliferating. Hypertrophy of the cartilages here affords a field for the deposit of lime salts, and the hypertrophic bony enlargement is closely bound up with the development and increase of the marginal ecchondroses already alluded to; their growth goes on superficially, while ossification takes place in the deeper layers by a process similar to physiological ossification. These lumps internally, then, are bony; superficially they are cartilaginous. Growing out with surprising rapidity, they form a buttress-like growth which speedily restricts the motion of the joint; although true anchylosis rarely or never takes place, the stiffness and loss of joint movement being due to this overhanging bony growth.

Extra-articular changes.—Degeneration of the ligaments takes place early in the affection—they first become inflamed, then thickened and degenerated into a substance like fibro-cartilage or elastic tissue, and in this stage the joint may show marked lateral mobility; and finally, at the attached border of the capsule as well as in the ligaments themselves, there begins a dense bone formation which contributes to the ensheathing bony mass. The osteophytes are more rounded and flat than one is accustomed to see in bone formation, after fractures, *e.g.*, and from the fact that ossification is not preceded by any especial vascularity, the new-formed bone is more dense and compact than normal; the tissues ossify just as they are. The muscles controlling the joint atrophy, from disuse largely, and the tendons are "absorbed" as well as the intra-capsular ligaments. "The absorption of tendons is best illustrated in the shoulder, where that part of the long tendon of the biceps which lies within the capsule is often found displaced from its groove and frayed out, or completely worn through, and its two ends, separated by a considerable interval, are adherent to the subjacent bone."

There is oftenest at the commencement more or less synovial effusion, but suppuration practically never occurs, and synovial effusion occupies at most a subordinate place. In the late stages there is apt to be periarticular œdema of the affected joint, and the skin, even before that, becomes thin and drawn, and shows most plainly the deformed outline of the joint.

Exostoses. Exostoses of the articular ends of the bones are rarely large enough to affect the joint, except by involving tendons in their growth. They are of two kinds: first, small spur-like processes or rounded projections, the result either of an inflammatory process, or of a simple hypertrophy; and, second, several large lobulated, spongy masses of bone called diffused osteoid tumors, which occasionally involve and destroy a joint, as in the cases of Paget [60] and Lancereaux,[29] where the knee-joint was so badly involved by the growth of one of these osteoid tumors from the tibia and femur that amputation became necessary. In structure they all show typical bone formation, and both classes belong rather to the order of pathological curiosities.

Morbid Periosteal Growth. There is, of course, a certain amount of formative osteitis of the articular ends of the bones accompanying tuberculous and syphilitic disease of the epiphyses, from the deposit of either tubercles or gummata in the periosteum, and oftener perhaps from the simple morbid activity of the periosteum. Thickening of the great trochanter in hip disease, *e.g.*, is a well-marked physical sign in most cases.

IV. DISEASE OF PERIARTICULAR STRUCTURES AFFECTING JOINTS.—(*a*) *Ligamentous Affections.*—It was formerly thought that diseased ligaments were often the cause of chronic joint disease. William Adams wrote: "Strumous joint disease commences most frequently in some of the ligaments of the joints." To-day we know that the commonest beginning of chronic joint disease is in the bones; yet the fact remains, that a wrench or sprain causing evidently injury to a ligament (of perhaps ever so slight a character) is sometimes the starting-point of a chronic joint affection.

Ligaments are as slow to repair as they are to inflame; occasionally they are found in a state of inflammation, in which case they are thick and pulpy, even when no laceration has taken place. In gout they may be the seat of the deposit of chalk-stones (tophi) before other localities are affected.

(*b*) *Periarticular Abscess.*—Suppuration in the peri-articular cellular tissue and subsequent affection of the joint, may start from an open skin-wound which has been infected, or from an injury to the limb where cellulitis has come on in consequence of the trauma. Again, in children of feeble type, periarticular abscess of a slow and chronic character is not unlikely to arise after slight bruises, and sometimes after no perceptible injury at all. Any of these abscesses, if they are not at once evacuated, are, of course, likely to infect a neighboring joint; occasionally, the abscess from one diseased joint burrows a long distance, and in its course either opens into another joint or passes so near to it that infection of the second joint takes place. This may follow psoas abscesses, where the pus travels near enough to the hip to infect it. This explains a certain number of the cases of hip disease secondary to Pott's disease.

(*c*) *Inflammation of Bursæ.*—The inflammation of bursæ from wounds, bruises, or constitutional causes, may lead to the secondary inflammation of the joints with which they happen to connect. For example, the large bursa between the neck of the glenoid process and the subscapular muscle is ordinarily in connection with the shoulder-joint, as is the case more rarely with the bursa under the deltoid. The bursa beneath the triceps tendon is oftenest a prolongation of the elbow synovial membrane. The bursa under the psoas and iliacus tendon frequently communicates with the hip-joint, and the bursa in the popliteal space often communicates with the knee-joint. These are the common paths of communication, but at most joint disease is rarely caused in this way.

As other causes of impairment, rather than disease, of joints, may be mentioned the following: cicatrices after burns, wasting of muscles and ligaments after infantile paralysis, and muscular contractions causing malpositions of the joints after hemiplegia, etc.

JOINT AFFECTIONS DEPENDENT UPON A CONSTITUTIONAL DISEASE.—Joint affections may be simply the local manifestations of a constitutional disease as in rheumatism and gout, and to a certain degree in malignant disease and syphilis.

Tuberculous affections are primarily local, but dependent on a diminished power of resistance on the part of the patient. A consideration of this view of the subject is important.

(*a*) *Tuberculosis.*—It was noted, in speaking of the chief class of degenerative osteitis, that microscopical evidences of tubercle structure were found, and that, moreover, tubercle bacilli in small numbers were almost always present in the same group. The importance of inoculation results is perhaps of more consequence in establishing the etiology of this affection than either of these others.

Hueter injected sputa from phthisical patients and detritus from tubercular glands into the joints of dogs, and found that it excited in them a synovitis hyperplastica granulosa, as he terms it, of the same type that one finds in tumor albus, etc., of the human subject. From this focus a general tuberculosis often developed, and caused the death of the animal.[26] Also, he introduced the granulations from a human tumor albus into the circulation of several dogs, and caused, with much regularity, general miliary tuberculosis. Schüller [61] threw further light on the relationship between joint affections and general tuberculosis by the following experiments: Guinea-pigs and dogs were rendered tuberculous by inhaling solutions of phthisical sputa and tuberculous detritus for half an hour a day for several days, and by the occasional injection into their lungs of the same solutions. The knee-joint of each was then wrenched or violently contused, and, with a few exceptions, a synovitis granulosa hyperplastica of a purely tuberculous type followed in the injured joint, while but few tubercles were found in the lungs. Similar injuries to healthy animals caused no such joint disease. Barwell [62] takes exception to these experiments, and considers that Schüller's experiments conclusively prove "that a tubercular state of the body does not produce joint disease. In other words, the earlier phases of joint disease are not tuberculous," chiefly on the ground that in only six of the twenty-four animals were structures like tubercles found in the granulations of the diseased joints, and these structures Barwell considers as purely inflammatory. He is, however, the only author of note who rejects Schüller's very careful work, and his article is not convincing or modern.

Müller [63] showed very clearly the channel of infection by which the bacilli enter. Tubercular material was injected into the femoral artery of sixteen rabbits with no results, next into the crural arteries (whence come the bone-nutrient arteries) of ten other rabbits, and in some of them were found tuberculous bone lesions. Finally, the nutrient arteries were found, and into them alone the tuberculous material was injected in twenty goats, and were dispersed there. The germ alone yielded positive results. Most of those whose arteries were injected showed typical local tuberculous disease of the ends of the bones. One young goat was well for four months, then he began to limp, and at the end of thirteen months his knee joint showed a typical fungous joint disease, beginning as a cheesy focus in the bone, with a wedge-shaped sequestrum and several tuberculous foci around.

Schuchardt, on the other hand, failed to produce tuberculosis in animals by the injection of fungous material into their circulation. Garré, using the pus from cold abscesses, usually of joint origin, found specific bacilli present in only a small number, and attempts at cultivation in these gave no results; but this pus injected into animals caused general tuberculosis. More recently still, Tresse put pathological sputa and pus from the cases of diseased joints into the epiphyses and diaphyses of the bones, with the result of starting up a disease like bone tuberculosis in the human being, and once a knee injection caused also a synovitis.

Burdon Sanderson and Klein have obtained practically the same result from inoculation experiments, and those of Villemin are historical.

So much for experimental inoculation in animals. The generalization of tuberculosis from a diseased joint in the human subject is a process unfortunately of such common occurrence that it can be passed over very briefly, and it shows even more clearly than experimental inoculation the relationship of tuberculosis and this class of joint diseases. A few figures may show the great liability of this. Billroth found that fifty-four per cent. of patients dying with this form of joint disease died of acute miliary tuberculosis; Jaffé that fifty-three per cent. of the deaths are from general tubercular infection. Gibney's extensive statistics show that in hip disease tuberculosis is, in spite of antiseptic precautions, the commonest cause of death. Nor does the removal of the diseased joint seem to diminish this liability very much. König did 117 resections for this class of joint disease, and of 25 deaths he found 18 due to general tuberculosis, and 9 more patients hopelessly tuberculous; and he has more recently called attention to the danger of "operative tubercular infection," where, by opening the lymphatic and blood channels in an operation which at the same time stirs up the focus of disease, tuberculous material is carried over the body, and general tuberculosis results.

Caumont found no preventive effect in resection, for in twenty-six cases of hip disease, treated expectantly, one-fifth died of generalized tuberculosis, while twelve others were resected and one-third died of the same cause. Yale says, in quoting it, "Others may have had better results, but the prophylactic effect cannot be very decided if such marked exceptions occur." Esmarch agreed with König as to the small preventive value of resection.

In the causation of this form of joint disease, characterized by this formation of tubercles and this tendency to generalize, much stress has always been laid upon the inheritance of what has been called a "scrofulous tendency," an inherited vice of constitution. The use of the word "scrofula" has intentionally been avoided here, and the reader is referred to Mr. Treves' "Manual of Surgery" for a discussion of the relation of scrofula and tuberculosis. "The modern view holds, although by no means is this generally accepted, that 'tuberculosis' is a definite infectious parasitic disease, and that scrofula—although presenting certain modifications arising from the difference of the tissues in which it is seated—is, from a pathological point of view, identical with tuberculosis." In accordance with this view, the word scrofula will, therefore, not be used in speaking of this class of joint diseases, as referring to the inheritance of tuberculosis, or a tendency to it, from the parents.

Experimental investigation has shown clearly enough the possibility of the transmission of tuberculosis from parent to offspring. Landouzy and Martin, taking a six-months' fœtus born of a phthisical mother, found it to all appearances perfectly free from tuberculosis; yet a piece of its lung put into a guinea-pig's stomach caused general tuberculosis in four months, and inoculation was then carried through five animals. The cardiac blood from another fœtus caused the same tuberculosis in other guinea-pigs. Again, one of these tuberculous guinea-pigs gave birth to a litter, and a young one of two days was killed and appeared perfectly healthy, yet pieces of its viscera inoculated into other guinea-pigs caused general tuberculosis. And finally, the semen of a guinea-pig thus rendered tuberculous was removed from the vesiculæ seminales with much care, and being inoculated into other guinea-pigs, it soon caused tuberculosis.

It is, of course, impossible to determine what proportion of children inherit these diseases or a tendency to them. Gosselin analyzed 300 cases of different tubercular joint diseases, and found tuberculous disease in one or both parents in sixty-eight per cent., and what he calls an "acquired diathesis" in thirty per cent. more; and of the whole number, after a close investigation, he could only find one case which did not present an acquired or hereditary diathesis; but he represents an extreme point of view in the matter. C. Fayette Taylor, in the analysis of 845 cases of Pott's disease, found thirty-four per cent. where there was tubercular or so-called scrofulous disease in the parents, and in sixty-six per cent. the disease came on in patients of a sound diathesis.

In 401 cases of hip disease from the Alexandra Hospital Reports, twenty-four per cent. had phthisis in the family history, and thirty-five per cent. were classed as traumatic. Albrecht, tabulating 825 cases of tuberculous disease of various joints as to etiology, classed thirty-three per cent. as "associated with scrofula."

The chief opponents of the point of view that these joint diseases are oftenest the results of inheritance are those who hold, on the ground of experiment, that the common cause is an injury to the joint. We have seen that trauma to the joint of a tuberculous animal will cause tuberculous joint disease, but that it does not do so in the healthy animal. It has been established that contusions and wrenches cause the effusion of blood in the spongy tissue of the bone. König has seen cases where tubercles developed directly from the clot, just as in a syphilitic individual a gumma will develop at the site of an injury to the bone. "There are cases where the swelling from the fall merges into the tuberculous swelling."

The fact remains that joint disease of a tuberculous type often follows injury in the case of children whose family histories are exceptionally good. Such cases must come under the observation of every surgeon. König estimates half the cases as traumatic; Albrecht, one-sixth; Croft, thirty-five per cent.; Gibney, forty-two per cent. (of which seventy-two per cent. were also hereditary); Taylor, fifty-three per cent. on 845 cases; and Sayre still represents the extreme view on this side in maintaining that practically all are traumatic. Gibney observed 845 cases of spinal paralysis in a class of children subject to constant falls and injuries, for several years, and found only 4 complicated with joint troubles. Roser observed 100 children at Marburg with fracture of the elbow, and in no case did tubercular disease follow. Stadler says, "Experience proves that traumatism excites only acute disease as a rule. In those constitutions strong enough to resist and repair the injury, these acute troubles soon subside. Under reverse circumstances they are apt to be followed by a chronic form of inflammation which may end in suppuration." There is no authority in the matter; the views of the most eminent men are but expressions of opinion. Adams, Agnew, Barker, Sayre, Petit, represent the advocates of traumatism. S. D. Gross believed that it could not exist without a vitiated constitution. Volkmann says, "Individuals with fungous joint disease spring practically without exception from families in which scrofula and tubercle are hereditary." That such is the rule, but that exceptions are common, is the view held by Schuchardt, König, Howard Marsh, Roser, and the majority of modern writers.

Exanthemata. A certain number of cases of joint disease of this type develop after the exanthemata. Gibney sets it at eighteen per cent., and Croft at 7½ per cent.; but the subject has been but little investigated.

Distribution. The frequency with which different joints are affected can only be learned by the consideration of large groups of cases. Schuller[80] gives the following table from 439 cases of Socin and his own: Knee, 35.8; hip, 15.9; elbow, 12.7; tarsus, 11.8; foot, 9.6; hand, 6.2; shoulder, 4.1 per cent., etc.

Billroth and Menzel[81] in 1,996 cases found the distribution as follows: Vertebral column, 35.2; knee, 11.9; head bones, 10.2; hip, 9.4; sternum, clavicle, ribs, 9.2; ankle and foot, 7.5 per cent.

Of 421 cases observed at Basle[82] 265 were classed as caries, and 156 as fungus disease, and their location was

Caries.	
Head	8.3 per cent.
Pelvis...........	33.6 " "
Upper extremities	22.3 " "
Lower extremities	33.6 " "
Multiple	2.2 " "

Fungus Disease.	
Upper extremities	25.6 per cent.
Lower extremities	74.3 " "
Hip	41 " "
Knee	50 " "
Foot	25 " "

Gibney, in 614 cases, mostly in children, found 209 cases of spinal disease; 271 cases of hip disease; 103 cases of knee disease; 31 cases of ankle disease.

Five hundred and thirty cases of chronic joint disease of this type in children have been observed in the surgical out-patient department of the Boston Children's Hospital, in the last three years, and they have been located as follows: Hip, 220; knee, 64; ankle, 36; vertebral column, 202; shoulder, 3; elbow, 1; wrist and fingers, 4.

At the New York Orthopedic Dispensary, dealing also almost wholly with children, from 1884 to 1886, inclusive, there were observed 2,644 cases of chronic joint disease of this type, in which there were 1,178 cases of hip disease; 1,024 of vertebral disease; 83 of ankle disease; 319 of knee-joint disease; 7 of wrist disease; 11 of elbow disease; 11 of shoulder-joint disease; 11 of multiple joint disease.

Age. Tuberculous joint disease is pre-eminently a disease of childhood. It is rarely, if ever, congenital,[55] and under one year it is not common. Of Gibney's 860 cases, so often alluded to, 84½ per cent. of all cases occurred before fourteen. Of 619 cases of hip disease tabulated by Mr. Wright,[83] there were:

Under 6 years	40 cases.
From 6 to 10 years............	110 "
" 10 to 15 "	129 "
" 15 to 20 "	66 "
" 20 to 25 "	39 "
" 25 to 30 "	17 "
" 30 to 35 "	9 "
" 35 to 40 "	4 "
" 40 to 50 "	3 "
" 54 to — "	1 case.
Total........................	418 cases.

And

Two years and under...........	28 cases.
From 2 to 5 years............	62 "
" 5 to 10 "	81 "
" 10 to 14 "	30 "
Total........................	201 cases.

Mr. Bryant has tabulated 360 cases as follows:

Under 4 years	126 cases.
From 5 to 10 years............	97 "
" 11 to 20 "	86 "
" 21 to 30 "	27 "
" 31 to 40 "	13 "
Above 40 years.................	11 "
Total........................	360 cases.

Taking Mr. Wright's and Mr. Bryant's cases, and adding 365 others reported by Dr. Sayre,[84] we have 1,344 cases of hip disease, of which 1,000 occurred under fifteen years of age. This is perfectly natural, for the tubercular diseases affect the growing epiphysis or the epiphyseal junction during the period of activity, and tuberculosis of all sorts is common in childhood.

The records of the New York Orthopedic Dispensary show the liability at different ages in the cases of joint diseases of the leg treated for the years 1884–1886:

	Under 3.	3 to 5.	5 to 10.	10 to 15.	15 to 20.	Over 20.
Hip	115	316	509	140	47	51
Knee.......	43	69	94	28	22	63
Ankle......	12	18	24	18	4	7
	170	403	627	186	73	121

The liability of the aged to tuberculous joint disease must, however, not be overlooked. The fact that people over sixty are more often "scrofulous" than people between thirty and fifty, is noted by Sir James Paget.[85] The patients may be seventy-five or ninety, and cases of hip disease present the same pathological appearances here as in young children. Paget speaks of the affection as one which he frequently meets. The course of the disease is naturally more rapid and destructive than in the young.

There is probably a slightly larger proportion of tubercular joint disease among boys than among girls. Of 619 cases of hip disease collected by Wright, there were 371 males. Holt,[73] in 2,307 cases of hip disease, found 1,178 males and 1,129 females, but the preponderance is very slight, and Mr. Bryant thinks one sex as liable as the other. Barwell thought that the presence of phimosis in a measure accounted for this preponderance of males in hip disease, at least, and in 100 cases of hip disease he found 83 in a condition of more or less complete phimosis. Wright examined 63 cases taken at random, 12 of which were hip disease, and he found, although the number is too small to generalize from, that in the hip-disease cases sixty-seven per cent. had phimosis, while in the others only fifty per cent. Dr. Sayre is also an advocate of phimosis as an exciting cause of hip disease, but its true place has yet to be settled.

Quiet disease, a term applied by Paget, simply refers to a class of tuberculous joint disease characterized by absence of all characteristic symptoms. Muscular fixation is present, however.

(*b*) *Joint Complications in Acute Infectious Diseases.*—The acute infectious diseases in which joint complications occur are as follows: Measles, scarlet fever, smallpox, typhus fever, typhoid fever, cerebro-spinal meningitis, pneumonia, dysentery, diphtheria, erysipelas, epidemic parotitis, pertussis, puerperal fever, pyæmia, septicæmia, malaria, gonorrhœa, and after the use of catheters and sounds.

The pathological appearances are those of acute and chronic serous or purulent synovitis of one or several joints. Sometimes the inflammation assumes a pseudomembranous character, as occasionally in scarlet fever and puerperal fever. The infectious material ordinarily reaches the joint through the circulation, but sometimes, as in puerperal fever, acute infectious osteomyelitis, and erysipelas, it comes from separate foci of disease, either by the lymph-channels or by direct extension.

These diseases are now almost universally attributed to the presence in the joints of micro-organisms of infectious character. Such theories as that of William Ord, *e.g.*, that gonorrhœal synovitis is the result of reflex nerve disturbance, have not enough in their favor to make them acceptable in the present tendency of pathology. Micro-organisms are found in the diseased joints and in serous synovitis, their character differing from those in purulent synovitis. It seems as if the question of whether the synovitis were to be a mild serous one, or a violent destructive purulent form, was determined by the kind of micro-organism reaching the joint, rather than by the especial infectious disease which may be present. In serous effusions one finds the organisms which characterize the especial disease present, and in greater or less number different forms of pyogenic cocci; whereas in purulent and phlegmonous processes one finds exclusively such regarded as simple but except pyogenics in enormous numbers. These facts have been established in the joint diseases of scarlet fever, acute infectious osteomyelitis, puerperal fever, etc. It is suggested that the synovitis of rheumatism is of the same character, but no evidence in support of the theory has been adduced. Gonococci alone have been found in gonorrhœal synovitis, but as a purulent urethritis not uncommonly supervenes, it must be assumed that pyogenic organisms reach the joint. The fact that synovitis occasionally follows urethral irritation, where gonorrhœa is not present, is well established, e.g., after dilatation for stricture.

Joint complications occur oftenest during the full course of the general disease, when they are apt to be polyarthritic, but in scarlet fever they generally come on at the time of desquamation, and in small-pox in the suppurative stage. In other affections they are commonest toward the end of the disease, as in diphtheria, after weeks or months of gonorrhœa, and late in dysentery as well. Of course they only occur in a very small proportion of all cases; coming late in the disease they are much more apt to affect only one joint.

But little is known of the general liability of the different joints; the knee is, however, clearly the one most often attacked. With regard to scarlet fever Thomas found the small joints of the extremities oftenest attacked, while Gerhardt, in his cases collected, found the larger joints of the upper extremity most liable.

Nolen collected, out of literature, 118 cases of gonorrheal joint affections (111 men and 7 women), which affected 308 joints in the following relation: knee, 86; foot, 52; shoulder, 29; hand, 26; fingers and toes, 17; metatarso-phalangeal, 16; hip, 15; elbow, 13, etc. One joint alone was affected 21 times; two joints were affected 12 times; three joints were affected 12 times; many or all joints were affected 15 times.

(c) *Rheumatism.*—Rheumatic joint affections attack oftenest the knee, then the foot, elbow, hand, shoulder, hip, etc. They are monarticular or polyarticular, and are either the outcome of an acute joint rheumatism, or an affection beginning spontaneously, or more rarely resulting from some injury.

The structure attacked is chiefly the synovial membrane, which secretes much fluid and takes on the appearances of chronic proliferating inflammation, with a tendency to connective tissue formation. In long-continued cases the cartilage shows the signs of chronic inflammation; thickening of the ends of the bones is not uncommon. The whole tendency is away from suppuration and toward connective tissue formation. One form, which Schüller calls arthritis rheumatica ankylopoetica, shows but little or no effusion, but a tendency to the formation of fibrous, and later bony, anchylosis. This ordinarily occurs in people of lowered vitality through want, or the use of improper food.

Often what appears to have been originally simple chronic rheumatism shows the signs of arthritis deformans. For the most part, purely rheumatic affections attack youths and persons of middle age (Schüller). The article on Rheumatism deals with the more general manifestations of the disease.

(d) *Arthritis deformans* (or rheumatoid arthritis) is characterized by the clearly marked series of changes described as the chief group in formative osteitis. It is both monarticular and polyarticular, oftenest the latter, and its victims are selected from those who are between the middle aged and old; retrograde changes in nutrition seem to be essential for its development. How much of the disease is of nervous origin and how much is rheumatic, is entirely unknown. Joints are attacked in the following order: knee, hip, shoulder, elbow, hand, foot, etc. (Schüller); others place the hand and finger joints first in frequency.

It is more common among men than women, and women whose catamenia have ceased early are especially prone to the disease. It is not unknown, however, among children, perfectly typical cases occurring in them.

It may seem to be set up by injury, by dampness or insufficient food, and often no cause at all can be assigned for it.

Attacking the hip, it is known as "malum coxæ senile," a perfectly well-defined affection clinically.

(e) *Gout.*—The joint affection, which is the manifestation of the constitutional malady known as gout, generally begins as an acute affair, and then settles into a chronic inflammatory process, increased by repeated exacerbations. The synovial membrane first presents the appearances of acute inflammation; the cartilage also shows a tendency to inflammatory degeneration and necrosis, and on its free surface and in its tissue appears a deposit of urate of soda, as well as in the capsule and periarticular structures, where localized deposits are known as "tophi." Bony anchylosis may occur, and there is but little tendency to suppuration, unless the calcareous deposits ulcerate through the skin by pressure and act upon the periarticular tissue. The common seat of the affection is the metatarso-phalangeal joint of the great toe. Scudamore found one hundred and forty out of one hundred and ninety-eight cases to start there; and from that joint it tends to invade the other joints of the foot, the joints of the hands, and the knee and elbow joints. The article on Gout deals with the etiology and general manifestations of the disease.

(f) *Syphilis.*—Joint inflammations in syphilis occur at three stages of the disease: (1) In the early secondary stage; (2) in the tertiary stage; (3) in hereditary syphilis. Each of these forms must be mentioned separately.

(1) Coincident with the skin eruptions, the sore throat, the iritis, etc., of the early general manifestation of the disease, there is occasionally, though not commonly, seen a simple serous synovitis. No post-mortem examinations of joints in this condition are recorded. The joints most commonly affected are, in the order named, the knee, hand, elbow, foot, and fingers.

(2) In tertiary syphilis there are two manifestations of what is practically the same pathological process. The development of gummata in the peri-synovial tissues, with chronic hyperplastic synovitis, and later, cartilage destruction. And secondly, the development of gummata in the bone and a secondary affection of the joint, as we have seen under degenerative osteitis.

(3) The joint manifestations of hereditary syphilis fall under four classes, which are sufficiently well marked to be considered separately.

A simple serous synovitis attended with much effusion, and a tendency to cartilage necrosis in spots; the capsule may be more or less thickened, but the epiphyseal cartilage remains normal.

An osteochondritis, with an accompanying epiphyseal periostitis and perichondritis, as already considered under degenerative osteitis, with its accompanying chronic synovitis and, worst of all, its tendency to separate the epiphysis from the shaft of the bone.

A chronic serous hyperplastic synovitis, with papillary growths and gummatous changes of the synovial membrane. And lastly, joint inflammation, the result of syphilitic osteitis, periostitis, and osteomyelitis of the long bones.

The classification followed is practically that of Max Schüller.

Syphilitic joint disease attacks oftenest the knee, then the elbow, the small joints of the fingers, and the toes, the metacarpo- and metatarso-phalangeal joints, then the joints of the hand, the hip-joint, the ankle, and the sterno-clavicular joints in the order named.

In 61 cases of syphilitic joint disease collected from various authors, the distribution was as follows: knee, [illegible]; joints of hands and feet, 20; the elbow, 12; and the remainder about equally distributed among the joints mentioned above.

(g) *Hæmophilia.*—Occasionally, in the peculiar diathesis known by this name, one meets with a unique kind of hæmorrhage from the synovial membrane of the joints, as well as from the serous membranes in other parts of the body. It comes on either spontaneously or in consequence of some injury, and affects oftenest the knee, elbow, and ankle. Fresh dark blood is poured out and the cartilage, ligaments, and synovial membrane are stained by it, and the cartilage shows a tendency to degenerate. Microscopical examination of the cartilage in the case reported by Mr. Legg, showed only the ordinary early changes of inflammation. All the changes seem purely the results of synovial hæmorrhage.

(*h*) *Rachitis.* — Rickets needs only to be mentioned as an occasional cause of joint disease. The swelling of the ends of the long bones is of course characteristic, and in addition to that the twisting and bending of the shafts warps and distorts the articulations, so that the whole bearing of the knee-joint, for instance, may be changed. The stretched ligaments yield, and incomplete dislocations may result.[92] A laxity of the peri-articular ligaments often occurs in the early stages of rickets.[93]

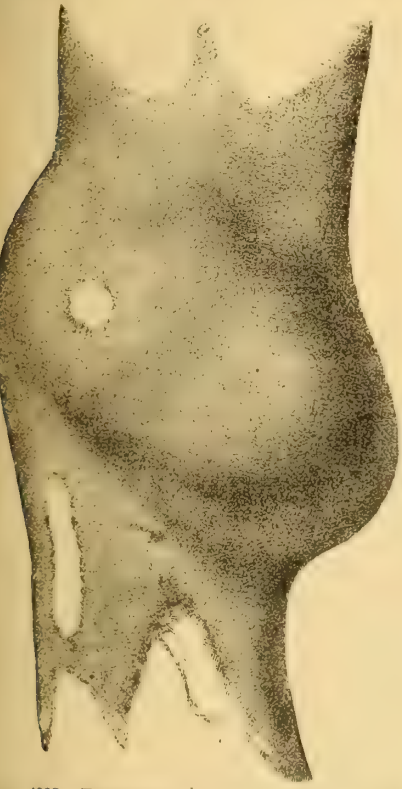

Fig. 4922.—Enlargement of the Knee-joint in a Case of Spinal Arthropathy. (Morrant Baker.)

Joint Affections Dependent upon Disease of the Nerves or Nerve Centres.—(*a*) *Spinal Arthropathies.* — Diseases of the joints dependent on diseases of the nerve or nerve centres are, as yet, but little understood. Cases, however, have been reported where local joint manifestations appeared to be secondary to the angular curvature of spino-hemiplegia, traumatism of the spine, and gunshot wound of the brachial plexus.

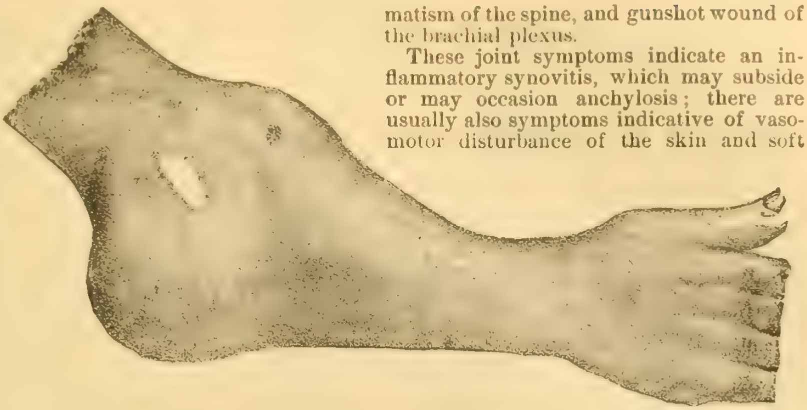

Fig. 4921.—Enlargement of the Elbow in a Case of Spinal Arthropathy. (Morrant Baker.)

These joint symptoms indicate an inflammatory synovitis, which may subside or may occasion anchylosis; there are usually also symptoms indicative of vasomotor disturbance of the skin and soft tissues, hyperæsthesia, etc.[94] In locomotor ataxia (tabes dorsalis) the joint symptoms are quite definite and characteristic.

Joint Affections in Tabes Dorsalis.—This affection, which was first demonstrated by Charcot, attacks the joints in the following frequency: out of 107 cases the knee was affected 78 times; the hip, 31 times; the shoulder, 21 times; the tarsus, 13 times; the elbow, 10 times; the ankle, 9 times; the wrist and jaw, each 2 times, and the spine, 1 time.

The joint symptoms usually appear suddenly, without known cause, and often without pain. The joint affection appears at an early stage of the disease of the spinal cord. The swelling of the joints may be quite large, and consist of an effusion in the joint, and an œdema of the whole limb. This often appears suddenly, and may subside, in part, with equal rapidity. There are, of course, severe and milder types. In the severe cases, the synovial membrane is pale and covered with granulations, the capsule is thickened and covered by a deposit of lime, and in the severest the capsule is entirely absorbed, and the ends of the bone are distorted, hypertrophied, or atrophied. The effusion is rarely purulent, and if so, it is due to violence. Luxation and spontaneous fracture may occur (Fig. 4923). The affection is, by Virchow and others, considered to be due to predisposition in the bones to faulty cellular change, resulting from the nervous disease of the spinal cord.[95] Pathologically, the morbid changes do not differ greatly from those of formative osteitis (arthritis deformans), except that the process may be much more extensive. The clinical course is ordinarily chronic, but it may become rapid and be attended by complete disability of the joint.

The treatment is, of course, only palliative. Rotter has excised the knee in four cases of this affection, with a fair result in two of the cases,[96] but such treatment must be only exceptionally indicated.

(*b*) *Functional Affections of the Joints.*—Under the different names of hyterical joints, hysteria of the joints, joint neuralgia, joint neurosis, neuromimesis of the joints, nervous affections of the joints, a disability has been classed which is characterized by pain, inability to use the limb, and at times marked stiffness of the joint. The affection is always chronic, and may be accompanied by distortion, which becomes permanent. The affection resembles, in many of the subjective symptoms, true organic disease of the joint, and differs from it in its course and objective symptoms. The trouble is usually idiopathic, dependent upon a condition of the nervous system; but it may follow trauma, and after fractures or sprains or

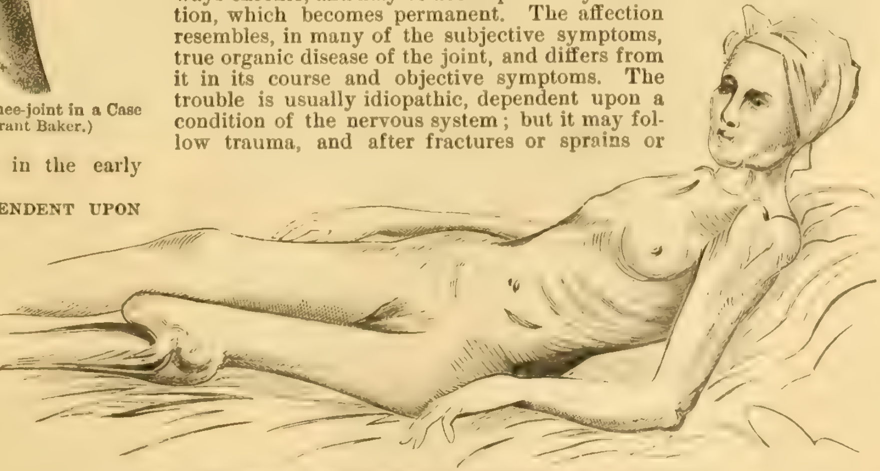

Fig. 4923.—Spontaneous Luxation in Spinal Arthropathy. (Schreiber.)

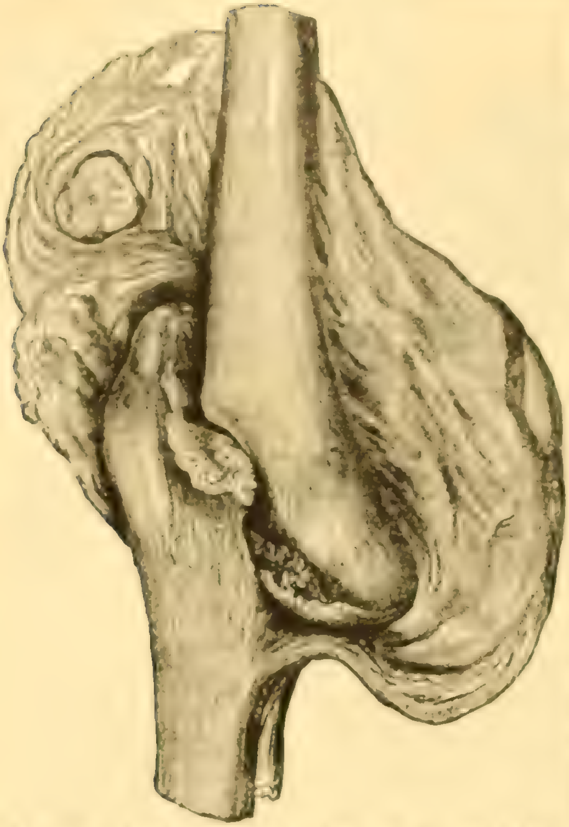

FIG. 2924.—Spinal Arthropathy of the Knee-joint. (Morrant Baker.)

severe injuries, an amount of pain or disability is complained of out of proportion to the actual organic disease, the result of a hyperæsthesia due to the injury, or to an amount of concentrated mental attention directed to the sensations of one part of the body. Any joint may be affected, but the hip, knee, and ankle are perhaps more commonly the joints complained of.

The affection, except in traumatic cases, appears gradually. The pain may be slight, but it is often severe and usually there are paroxysms of extreme pain at regular or irregular intervals, either dependent on motion or spontaneous while the limb is at rest. The pain may be a dull ache or a severe throbbing pain. The pain extends upward or downward and may be accompanied by paræsthesia or anæsthetic spots. The following points are frequently sensitive at the hip, viz., a point between the trochanter major and tuberosity of the ischium, and one at the anterior superior spine. In the knee the internal condyle, and on the inner side of the patella and above the head of the patella, there may be sensitive points. At the ankle, the points behind the malleoli. The affection is more common in women than in men. It may occur, rarely, in young children of a neurotic type.

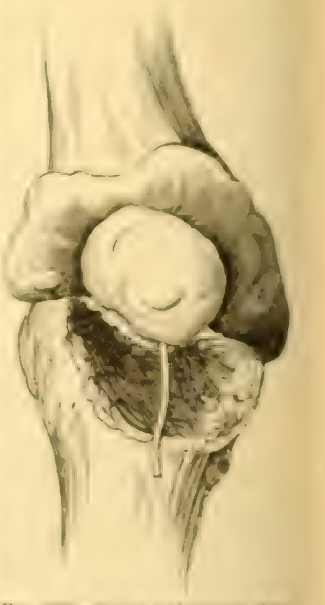

FIG. 2926.—Spinal Arthropathy of the Knee-joint. (Schreiber.)

Voluntary motion of the limb may be at times nearly normal, conscious motion of the limb may be extremely limited, and passive motion encounters resistance. Sensitiveness to pressure is great, and greater to superficial than to deep pressure.

Distortions of the limb are not common in the early stages, but may become habitual and finally fixed from adapted muscular changes. The patients complain sometimes of a sensation of grating at the joint.

A recognition of the affection is at times quite difficult. The diagnosis has to be based on a lack of correspondence between the severe subjective symptoms—pain, tenderness, sensitiveness—and the absence of evidence of organic changes—inflammatory destruction of bone, characteristic distortion. There is a lack of harmony between the symptoms presented and those found at any one stage of the usual joint affections. The limp is greater than would be found with the amount of unconscious active motion at the joint. The pain and tenderness are more severe than is usual at an early stage of the affection, unless it is unusually rapid and accompanied by marked swelling of the joint.

There may be slight periarticular swelling and occasional redness. These are, however, usually slight, and due to vasomotor disturbances rather than to true inflammation. There is but little or no muscular atrophy in functional affection of the joint, this condition being always present in true chronic diseases of the joint. There is no diminished muscular contraction to faradic irritation, as is the rule in organic disease of the joint. The pain, when present, is not as severe at night as in the acute stages of true joint affection.

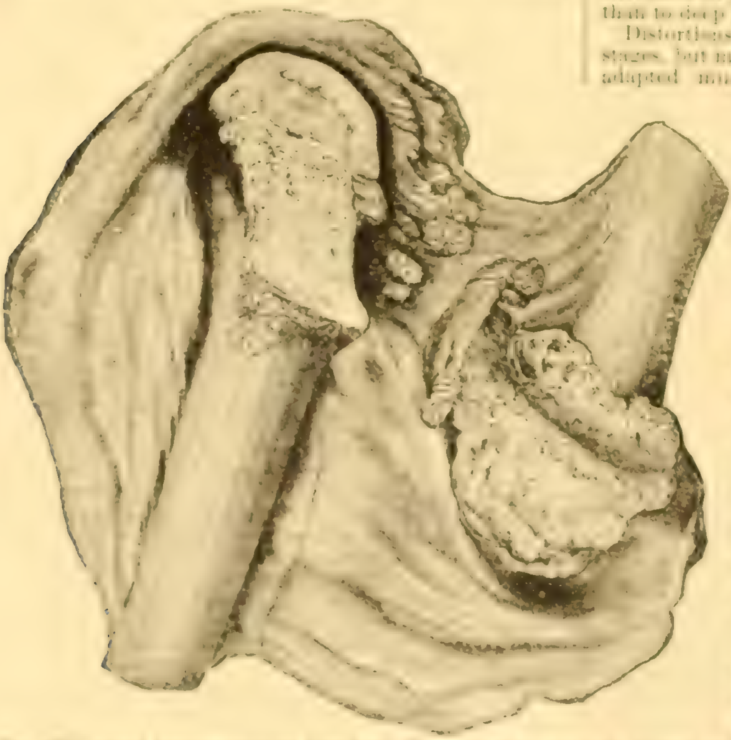

FIG. 2925.—Spinal Arthropathy of the Knee-joint. The same as the preceding, showing the [illegible] (Morrant Baker.)

There is rarely, in this affection, any conscious exaggeration or deceit on the part of patients. Whatever apparent exaggeration there may be is due to increased mental attention to symptoms, or to a local hyperæsthesia.

For the treatment the reader is referred to the subjects, Hysteria, Neuromimesis, as the treatment should not be local.

Growing Pains.—A joint affection incident to growth has been described by Bouilly, and has long been known but unclassified by practitioners, and is popularly considered to be incident to growth—"growing pains." There is slight pain, chiefly in the juxta-epiphyseal region, most commonly near the lower epiphysis of the femur. This pain is brought on by fatigue, strains, or exposure. In the lightest cases the symptoms pass away in a few hours. In severer forms they may last for several days, and the pain be accompanied by slight fever. In the severest form the affection may continue for months. There may be slight effusion in the joints, but recovery eventually takes place. It may occur during the ages between five and twenty-one.[97]

Acute Arthritis in Infants.—English writers have described, under the term of acute arthritis in infants, a form of acute epiphysitis or juxta-epiphysitis occurring in infants from two months to two years of age. It is of a particularly severe form. It is extremely fatal, death occurring in 13 out of 27 cases. Several joints may be attacked. The knee, hip, and shoulder are the ones most frequently involved. The joint at first is stiff, pain and swelling follow, and later an abscess is formed. Out of 27 cases, the hip was attacked 14 times, the knee 11, the shoulder 5, the ankle and elbow 4 times each, the wrist 1. Out of the 27 cases, in 20 the affection was monarticular.[11]

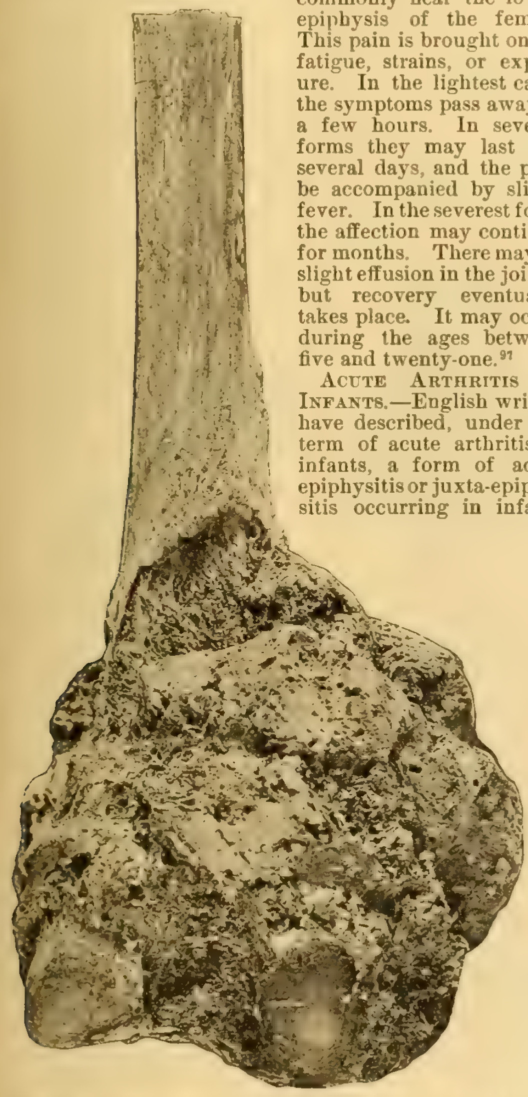

Fig. 4927.—Tumor of the Bone Involving the Joint. (From a Photograph.)

Tumors of the Joints.—Tumors involving the joints are malignant or benign. In the latter class are to be named exostoses, cartilaginous tumors, angioma, aneurism, and echinococcus. The last three are only pathological curiosities; exostoses have been considered under formative osteitis. Cartilaginous tumors grow from the peripheral or central part of the bone; they occur chiefly on the joints of the hands.

Malignant tumors are of vastly more importance. There is a tendency among certain writers (Billroth, Marsh, etc.) to identify all malignant joint tumors with sarcoma, ignoring the existence of carcinoma. The existence of primary cancer of bone is, however, attested by Virchow, Volkmann, Förster, Paget, and Barwell. Sarcoma is, however, vastly more common, and it occurs in many histological forms, round- and spindle-celled, myeloid, partly cartilaginous, and (rarely near the ends of the bones) partly ossified, as the osteosarcoma. The growth originates occasionally in the synovial membrane, ordinarily in the bones from the endosteum or periosteum. Sarcoma infiltrates soft parts of bone, and on section appears fleshy and mottled, being oftenest composed of myeloid or giant cells. The endosteal form, however, is ordinarily the spindle-celled form and grows less rapidly, absorbing the bone and having the appearance of having a capsule, which it really does not possess. Joint sarcomata affect chiefly young subjects from fifteen to twenty or twenty-five years of age. The joints commonly affected are the knee, the shoulder, and the wrist.

Anchylosis.—The loss of mobility in a joint may vary from a small diminution in its arc of motion to a complete obliteration of all movement. Some of the pathological processes that we have considered are perfectly capable of destroying the articular surfaces and replacing them by granulations. The granulations in turn are replaced by connective tissue "organized" directly from the granulation tissue. Consequently it is easy to see how fibrous bands of greater or less extent are formed, running from one bone surface to the other, and these in turn may ossify and a solid bony mass may be where there was at one time a joint. Oftener, fibrous and bony anchylosis are found associated with each other. In the form of synovitis characterized by a small fibrinous exudation (dry synovitis) the formation of fibrous bands between the joint surfaces is accomplished without the intervention of granulation tissue.

Other causes of the loss of motion in joints, besides fibrous and osseous anchylosis of the joint surfaces, are: 1, cicatricial contraction of the articular capsule and ligaments; 2, adhesions between the folds of the synovial sac, causing restriction of joint motion and secondarily degeneration of the cartilages, in consequence of inaction; 3, the buttress-like osteophytes in formative osteitis; and 4, in pathological luxations, the result of destructive bone inflammation causing loss of substance in the ends of the bones, and consequent malposition of the articular ends of the bones.

Bony anchylosis is of course oftenest the result of suppurative synovitis, primary or secondary, but not necessarily the result; for, of thirty-five cases of hip-joint disease analyzed with reference to the ultimate amount of motion in the joint in suppurative and non-suppurative cases, it was found that the presence or absence of abscesses had no effect upon the ultimate amount of motion left to the joint.[98] Marsh found bony anchylosis present in an ankle-joint one month after suppuration began.

On the other hand, as we have seen, true bony anchylosis may occur without suppuration at all.

Distribution of Joint Diseases.—Of 2,002 cases of all kinds of joint disease collected[103] from the clinics of Volkmann,[100] Langenbeck,[99] Hueter,[102] and Socin,[101] 1,387 were of the lower extremity, 615 of the upper.

The distribution of all the various forms among the special joints was as follows: knee, 711; hip, 333; foot, 234; elbow, 183; hand, 172; shoulder, 166; finger, 94; tarsus, 78; toes, 31.

Of 834 cases collected by Schüller,[103] as showing the frequency of the various kinds of joint disease, there were 240 cases (28.7 per cent.) of acute serous synovitis; 26 cases (3 per cent.) of acute purulent synovitis; 67 cases

8 per cent.) of simple chronic synovitis, 108 cases (16.3 per cent.) of arthritis deformans, 345 cases (51.5 per cent.) of scrofulous or tuberculous joint disease. Schüller estimates the general relation of acute to chronic joint disease as 1 to 8 in general, although hospital clinics would set it as 1 to 3. General acute joint rheumatism and metastatic inflammations are not seen here.

Two or more joints may be attacked at the same time, not infrequently in the affection known as chronic rheumatoid arthritis, but also in tuberculous disease.

CLINICAL HISTORY.—The clinical course of the different diseases of the joints, while varying somewhat according to the anatomical surroundings of the different joints, preserves its type sufficiently, so that a description of the disease in one joint will serve for that of another within certain limits. The best type of a serous effusion of a joint will be found in effusion of the knee-joint, while for typical tubercular osteitis of the joints the history of the larger joints, hip or knee, will serve; and the same is true of chronic rheumatoid arthritis. The subject will therefore be considered under the heads of the special joints.

DISEASES OF THE HIP-JOINT.—The clinical history of the diseases of the hip-joint varies not only according to the different affections, but also in the varieties of the same affections, according to the severity of the attack, the rapidity of invasion, and also, in all probability in chronic epiphyseal osteitis, according to seat of the primary lesion, that is, whether it is in the acetabulum, in the part of the epiphysis near the articulation proper, or in a part near the diaphysis.

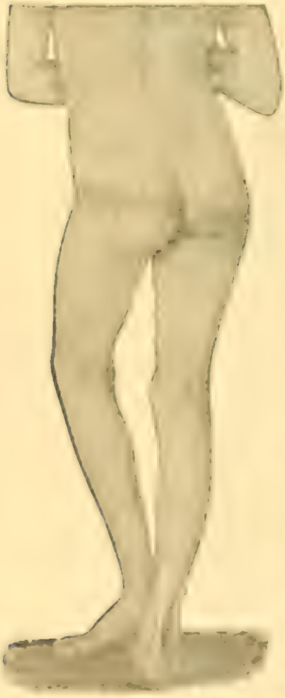

FIG. 4928.—Flexion and Abduction. (From a photograph.)

1. *Epiphysitis* (Morbus coxæ, Hip Disease, Morbus coxarius, Coxalgia, Coxitis tuberculosa).—The most common disease of the hip-joint is tubercular epiphysitis, occurring in the growing bone of children.

The beginning of the affection is usually gradual. The child will be noticed to limp at times. This lameness increases, and it will be found that the patient is inclined to strike the ball of the foot rather than the heel in walking; although the heel can be put down to the floor, yet instinctively the knee is slightly bent and the heel raised when the weight of the trunk falls on the hip. There is a certain amount of stiffness of gait apparent in the morning when the patient first gets out of bed, and after sitting for a while; this passes away after the patient has walked or played about. The symptoms may at first be unaccompanied by pain, but later there is an occasional complaint of pain in the knee. If the child be inspected it will be seen that, although able to run about and play freely, there is a noticeable limp, and in standing the knee of the affected side is usually flexed slightly, the pelvis being tipped, the thigh slightly abducted (Fig. 4928); the tilting of the pelvis and abduction of the thigh may be so slight that it is scarcely noticeable, except by the deviation from the median line of the fold between the two buttocks. In girls the vulva on the affected side will be seen to be lower than on the other side (Fig. 4929).

Lameness.—The symptoms gradually increasing, viz., limp in gait, stiffness, and slight pain, the patient may find difficulty in walking, and complain of rheumatism or "growing pains," which will pass away under friction or domestic remedies and rest, again appearing at irregular intervals.

The limb at this time will be found somewhat smaller in the circumference of the thigh than the other; there will be marked limitation of the usual free motion of the hip-joint, the pelvis moving on motion of the thigh, or moving on motion of the thigh beyond a limited arc.

Pain.—As the affection progresses, pain in the knee and sensitiveness in jarring the limb may become a prominent symptom—the pain being almost invariably located by the patient in the knee. The adductor muscles of the thigh will be found near the symphysis pubis to be prominent and contracted, and frequently there is a thickening of the tissues in Scarpa's triangle perceptible on palpation. An unconscious protection of the joint will be noticed in the movement of the patient; the foot of the well limb will be placed under the lower part of the leg when it is to be suddenly lifted by the patient, as from the floor to the bed, or from the bed to the floor, or in moving from one side of the bed to another. In walking, the patient instinctively avoids resting weight upon the limb, except for as short a time and with as little jar as is possible, the thigh being slightly flexed, the knee being bent, and the heel raised, so that the shock upon the acetabulum from pressure of the head of the femur when the weight of the body is thrown upon the limb may be broken at the knee and ankle joints, which serve as springs. This attitude of the limb—flexion of the thigh—becomes habitual and characteristic; to it is added in the earlier and acuter stages abduction and outward rotation of the limb.

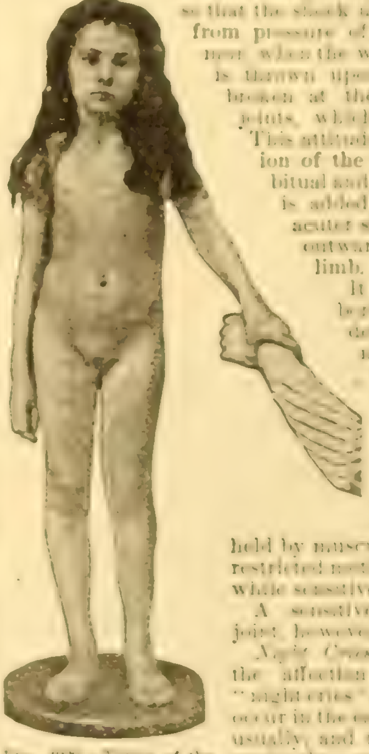

FIG. 4929.—Tilting of the Pelvis and Abduction of the Thigh in Hip Disease. (From a photograph.)

It should be always borne in mind that tenderness or sensitiveness at or about the joint may be absent, and the absence of these symptoms does not indicate the absence of well-pronounced disease. The joint may be firmly held by muscular spasm, allowing restricted motion on manipulation, while sensitiveness may be absent. A sensitive condition of the joint, however, may supervene.

Night Cries.—At this stage of the affection the symptom of "night cries" often appears. They occur in the early part of the night usually, and may become an exceedingly annoying symptom. After the patient is asleep and entirely unconscious, to all appearance, sleep will be interrupted by a loud cry as if of severe pain, followed by moaning or crying for a few seconds, the patient being unconscious or only half conscious of the cause of the pain. These do not occur when the patient is entirely awake, and are caused by the spasmodic twitching of the muscles abnormally irritable from irritation reflex to the inflammation of the joint. These cries may vary from a short moan to a piercing shriek, and may in the severest cases be repeated fifteen or twenty times during the night. They do not occur in the later stages of the disease, and may be entirely wanting in the mildest cases. They resemble somewhat the cry in the "night terrors" of nervous children, but differ from that in that there is greater evidence of extreme pain, and no connection with unpleasant dreams, apprehension, or fright. From the testimony of

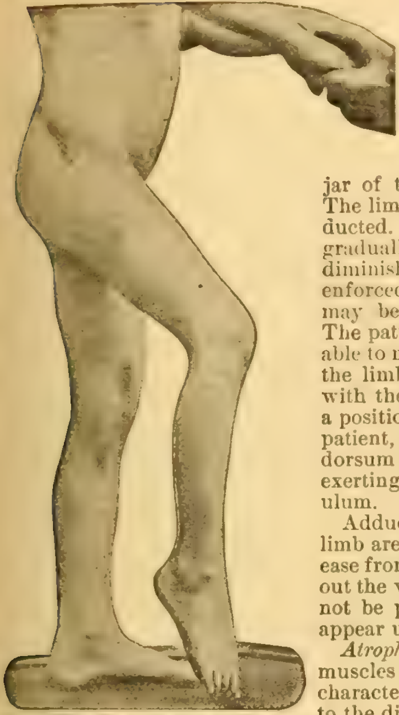

FIG. 4930.—Shortening and Flexion. (From a photograph.)

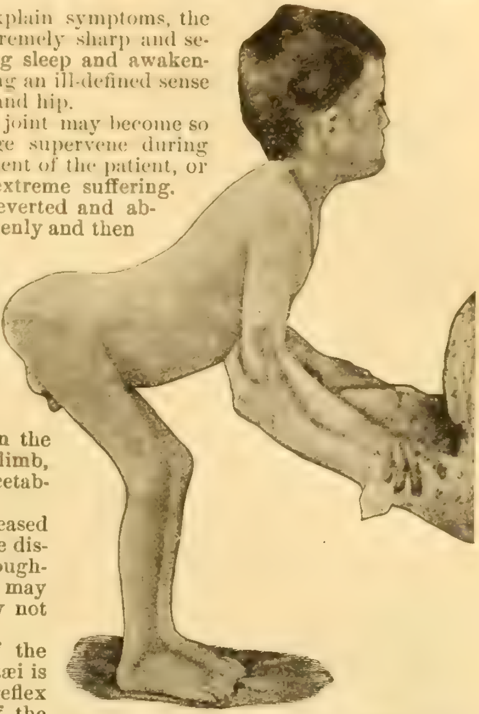

FIG. 4932.—Flexion in Double Hip Disease. (From a photograph.)

patients old enough to explain symptoms, the pain is reported to be extremely sharp and severe, suddenly interrupting sleep and awakening the patient, and leaving an ill-defined sense of an aching in the thigh and hip.

The sensitiveness of the joint may become so great, and an acute stage supervene during which the slightest movement of the patient, or jar of the bed or room, causes extreme suffering. The limb is flexed at the thigh, everted and abducted. This stage may come suddenly and then gradually pass away, the pain diminishing gradually under the enforced treatment of rest, but it may be prolonged for months. The patient will gradually become able to move the limb, or to steady the limb with the sound limb or with the hands. Characteristic is a position frequently taken by the patient, who places the well foot on the dorsum of the foot of the affected limb, exerting pressure away from the acetabulum.

Adduction or abduction of the diseased limb are neither characteristic of the disease from the first; they persist throughout the whole affection. Abduction may not be present, and adduction may not appear until late in the disease.

Atrophy. A marked atrophy of the muscles of the thigh and of the glutæi is characteristic. It is supposed to be reflex to the disease of the joint,[104] and if the muscles of the thigh are tested for contractility to the irritation of the faradic current, it will be found that the contractility is markedly diminished. The upper part of the thigh and the tissues in the vicinity of the hip may become swollen, particularly the lymphatic glands of the groin—an œdema of the periarticular tissues taking place, similar to that seen in the knee in the so-called "tumor albus;" this may disappear or become localized in the formation of an abscess.

Distortion of the Limb. Flexion of the thigh is a symptom which, noticeable even in the early stage of the disease, becomes more marked as the disease progresses. It was originally supposed to be due to an effusion in the capsule of the hip-joint, but it is seen together with adduction and abduction in cases where no effusion has taken place. It is chiefly due to the muscular contraction, which is constant in chronic disease of the joint, and partly to an unconscious effort on the part of the patient to assume a position most comfortable for the joint and most protected from jar.[56] In double hip disease flexion produces a terrible deformity (Fig. 4932). As the disease progresses adduction of the femur takes place, and the attitude of flexion and adduction is characteristic of the last stage of the disease (Fig. 4933).

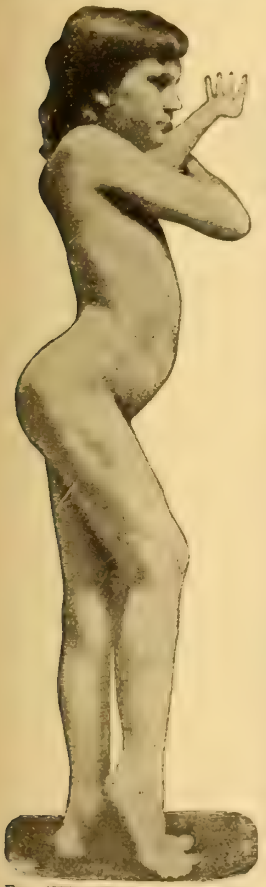

FIG. 4931.—Flexion in Hip Disease. (From a photograph.)

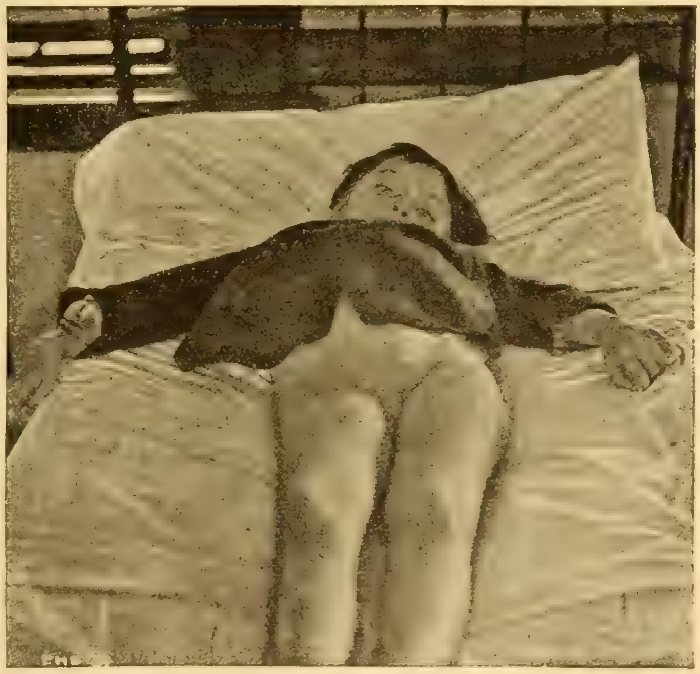

FIG. 4933.—Adduction. (From a photograph.)

Abscess.—In quite a large proportion of cases suppuration takes place. In the severe forms accompanied by much pain, by severe pain for a long period, suppuration is the rule. The site and course of the abscesses vary according to the seat and size of the original focus of the disease, in the femur or the acetabulum. Abscesses may be entirely periarticular, if the initial lesion of the epiphysis extend in a course outside of the joint; or they may come from suppuration within the joint; or having been periarticular, they may later involve the joint.

The formation of the abscess is frequently without constitutional disturbance, as is not infrequent in cold abscesses in general. Usually there is a slight fever. As the abscesses enlarge they are usually accompanied by the pallor incidental to suppuration—the suppurative leucocythæmia characterized by an increase in the number of white corpuscles. This condition may not interfere with a fair appetite and more or less satisfactory general health, but as a rule the appetite is capricious.

Abscesses may be absorbed spontaneously or may discharge themselves. They may evacuate themselves partly, and the residual fluid, following along the course of the sheaths of the muscles and the fasciæ, reappears later as a second abscess. In some cases the same abscess may even cause five or six fistulous openings.

Increased Intra-articular Pressure.—The effect of persistent muscular spasm of muscles about the hip joint, characteristic of hip disease, is to crowd the femur against the acetabulum. The amount of the force may be estimated as relatively great if we bear in mind the strength of the affected muscles. The result of this force is to produce the pseudo-luxation characteristic of hip disease, viz., the enlargement of the acetabulum and the absorption of the head of the femur, and the resulting shortening of the limb, and in certain cases the actual escape of the head of the femur from the socket.[4]

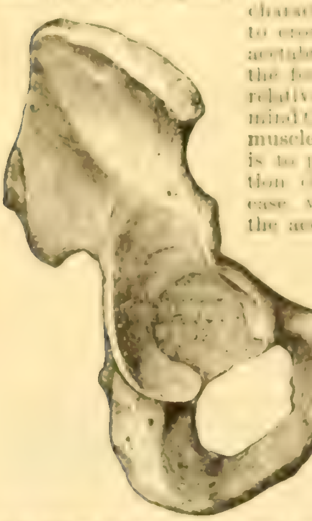

FIG. 2961.—Pathologically Enlarged Acetabulum.

Hip disease, like all diseases, is a self-limited one. A natural cure takes place in a majority of cases, but the cycle of invasion, efflorescence, convalescence, and cure always consumes a long period of time. The natural cure in the lightest cases leaves a slight limitation of motion in the hip. This is accompanied by a slight limp. More frequently there is practical stiffness of the joint, with fibrous or eventual bony ankylosis at the hip joint, flexion and adduction of the limb, with practical shortening. Subluxation of the femur with shortening of the limb is a common result of the natural cure, and an arrest of growth with actual shortening of the bone.

The openings of abscesses may close in time after the separation of sequestra; and in some instances a large sequestrum, constituting nearly the whole head of the femur, has been spontaneously evacuated, giving a useful limb.

Death in the course of hip disease takes place not infrequently from tubercular meningitis. Death may also be caused by exhaustion and the septic involvement or amyloid degeneration of various organs, liver, kidney, secondary to suppuration and abscess.

Acetabular Hip Disease.—It has been found that in a certain number of cases the disease begins, not in the epiphysis of the femur, but in the bony tissue of the acetabulum.

Pathologically, this class of cases becomes similar at an early stage to ordinary hip disease, as in the progress of the disease the head of the femur soon becomes involved. Clinically the cases differ somewhat, in that there is greater liability of perforation of the acetabulum, and the formation of pelvic abscess at an earlier stage than is common in the course of hip disease.

In focal disease of the hip joint, if the focus of osseous inflammation is situated in such a part of the epiphysis of the femur that, on extending, it evacuates itself into the periarticular tissue, rather than into the joint; or if the osseous inflammation is not rapid in its progress and is well limited by a surrounding ossifying circumferential osteitis, the symptoms of pain or sensitiveness will be absent for a long time, if present at all.

But in all these different types there is a common resemblance in the limb, in the peculiarity of attitude, flexion, abduction, and adduction, and the limitation of motion at the hip joint.

There is a certain amount of variation in the amount of deformity left in the natural cure of hip disease, depending upon the severity of the disease and the amount of bony destruction. The flexion and adduction may be so slight as only to cause slight shortening, or it may practically prevent the usefulness of the limb. A most distressing deformity follows the natural cure of double hip disease. This may leave severe flexion of both femora, or flexion and adduction so that the limbs are crossed.

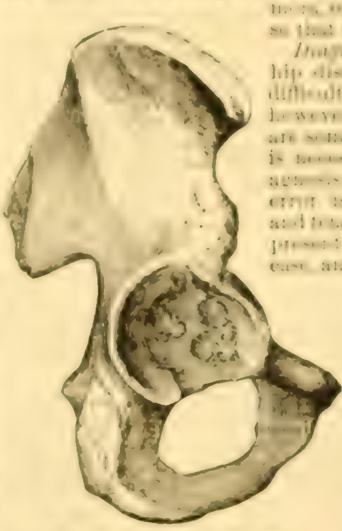

FIG. 2962.—Acetabular Caries.

Diagnosis.—Diagnosis of hip disease is ordinarily not difficult; in the earliest stages, however, errors in diagnosis are sometimes made, and care is necessary for a positive diagnosis. The most common error is the belief that pain and tenderness are necessarily present in all cases of hip disease, and that their absence excludes the possibility of hip disease. Pain and tenderness are not, however, early symptoms in a majority of cases.

Lameness.—A limp in gait is an early symptom, in fact the earliest symptom. It may be said that no hip disease can be present without giving rise to a limp in gait. At the earliest stages, however, the limping may be intermittent and not constant. The same may be said of a limitation of motion at the hip joint. A [illegible] that there can be no hip disease if the motions at the hip joint are perfect. In one case examined in the very earliest stages, which afterward proved to be hip disease, the motion at the hip joint on one examination appeared to be perfect; but on a second examination the next day, after a little exercise, it gave evidence of slight limitation of motion.

Muscular Stiffness.—It should be borne in mind that some care is required to discover slight limitation of motion in very young children, who are apt to resist thorough examination. The resistance to motion due to fright is, however, always resistance to any motion of the limb. If by slight force this is overcome, resistance to rotation of a flexed thigh, or to extreme flexion, will not be encountered. A comparison of the resistance of one leg with that of the other will reveal abnormal resistance. Limitation in motion at the hip joint in the early stages is recognizable at the extremity of the arc of normal movement. And there is limitation equally in motion in all directions, i.e., flexion, extension, abduction, or adduction. The normal amount of abduction is, however, slight. Resistance to motion in this direction, therefore, is an early test of importance. Extreme abduction, or abduction and rotation of the thigh flexed at right angles to the body, is also a delicate test.

In young and frightened children, the tests for limitation of motion at the hip-joint are best made with the child lying on the mother's lap, or leaning on the mother's shoulder; but ordinarily the best position is with the patient lying upon a hard flat surface.

A limitation to flexion is determined by flexion of the normal limb on the abdomen to its utmost limit, and afterward a repetition of the motion of the suspected limb. If the limb is then extended so that the popliteal space be placed upon the hard surface on which the patient lies, there will normally be no alteration of the position of the back; if, however, there is a contraction of the psoas and iliacus muscles, *i.e.*, a limitation in the normal extension of the limb, the back will be arched up as the popliteal space is pressed down.

This limitation to extension can also be determined by examining the patient lying upon the belly. If one hand be placed on the sacrum and the thighs be alternately raised from the surface on which the patient lies, a difference in the amount of motion at the hip without moving the sacrum can easily be determined. The limit to the amount of abduction or adduction is determined by placing one hand on the anterior superior spine of the ilium on the sound side, and with the other hand gently abducting or adducting the suspected limb.

Careful inspection in the early stages of hip disease will sometimes show fibrillary contraction of the muscles of the thigh on sudden or unexpected movement of the limb.

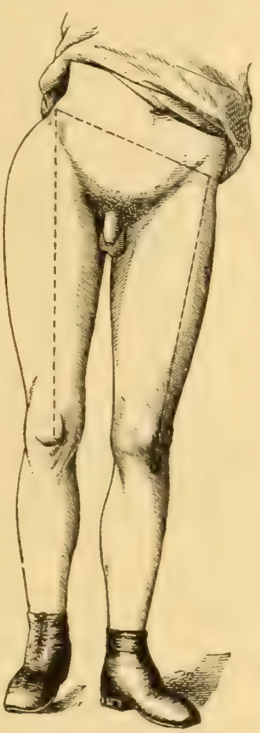

FIG. 4936.—Method for Estimating Abduction or Adduction.

In the later stages of hip disease practical anchylosis of the joint takes place, there being no motion at the hip-joint. This is due to muscular spasm and disappears under complete anæsthesia, unless a permanent degeneration of the muscle has taken place, or a fibrous anchylosis of the hip-joint has begun to be developed.

A limitation to rotation at the hip is not so readily detected in the earliest stages of hip disease. Often the foot can be turned in and out with apparently normal freedom; if, however, the thigh be flexed upon the abdomen, and an attempt be made to rotate the femur and at the same time abduct it, at a very early stage unusual resistance to this motion will be found on the affected side as compared to the normal side.

In examining the patient for muscular stiffness, the clothes should be removed and the patient should lie upon a hard surface (except in the case of an infant in arms, as above mentioned). Attempts to move the limb should be made gradually and gently and persistently—rough force only exciting resistance and making a delicate examination impossible. The most convenient order of motion in examination is first flexion, then abduction and abducting rotation with the thigh flexed, then extension. The suspected limb should be held at the ankle or knee.

Attitude. The peculiarity of the patient's attitude in standing or lying in bed—the flexion, abduction, or adduction of the limb—in marked cases of hip disease is pathognomonic. In the earlier stages this can usually be noticed on careful watching, and the peculiar care with which the patient moves and steadies the limb with the sound limb in getting in and out of bed, is of diagnostic importance.

The abduction of the limb is usually not recognized by the patient as abduction, but the complaint is made that the limb seems longer than the other. The pelvis is tilted, which gives a practical lengthening of the limb. In the same way the limb appears shorter to the patient if adducted. The tilting of the pelvis can be recognized by drawing a line from the anterior superior spine of one side to that of the other. This should be at right angles with a line from the umbilicus to the symphysis pubis.[31]

Atrophy. Atrophy of the muscles is an early symptom, and is determined by measuring the circumference of the thigh, or by inspection or palpation of the muscles.

The obliteration of the fold of the buttock mentioned in the older writers is due to this atrophy, but it is not always one of the earliest symptoms.

A diminution of the farado-electric muscular contractility in the muscles of the thigh is symptomatic of hip disease at an early stage.

The muscular atrophy of hip-joint disease differs from that of infantile paralysis in that it is not as great, and that the power of the muscle is not lost. The muscular atrophy is greater, as a rule, than that of simple disuse of the muscles.

In the earliest cases the atrophy may be so slight as to escape detection by the tape measure.

Pain. The pain in well-marked hip disease is almost invariably located at the knee; the cause of this is not certain, but it is probably analogous to the pain referred to at the end of a nerve in irritation in its course. Exceptionally, the pain is referred to the leg and follows along the course of the sciatic; pain located at the hip is exceptional and is usually indicative of suppuration or the pressure of an abscess under the fasciæ, or of nervous hyperæsthesia.

Tenderness on jarring the hip is rarely an early symptom. Sensitiveness on slight jar of the hip is sometimes indicated, previous to the presence of conscious pain, by an instinctive wincing on the part of the patient if the limb is jarred. The use of violently jarring the hip is unnecessary in the examination of a patient for hip disease.

The "night cries" characteristic of hip disease have already been mentioned; they are more common in an earlier stage of hip disease.

Swelling. In an early stage of hip disease there is, as a rule, no swelling, unless the affection is unusually rapid in its course.

The glands in the groin may, however, be found to be enlarged on palpation.

Swelling about the hip is not uncommon in the later stage of hip disease.

An apparent condensation or thickening of some of the superficial tissues, to be felt on palpation, usually can be found in hip disease at a comparatively early stage. It is common in the region of the tensor vaginæ femoris.

To recapitulate the symptoms on which a diagnosis of hip disease is based, they may be summed up as follows: 1, Limping; 2, limitation of motion or stiffness of the joint in all directions of normal motion; 3, peculiarity of attitude or distortion of the limb; 4, muscular atrophy; 5, pain or sensitiveness.

Differential Diagnosis.—A list of the diseases which have been mistaken for hip disease would be a long one. The table on page 350 indicates the means of making a differential diagnosis.

An error in diagnosis is only possible in the early stages, if an examination with ordinary care is made.

Sarcoma of the hip may at first be mistaken for hip disease, but there is greater hardness of the swelling than such as is to be met in early hip disease, and there is an absence of the usual symptoms of hip disease.

A differential diagnosis between chronic synovitis of the hip-joint and chronic epiphyseal osteitis is not possible at an early stage in the disease, and is not necessary, as the treatment is the same, though the prognosis of chronic synovitis may be somewhat better.

Periarticular disease, which has not yet attacked the

Diagnostic Table of Affections of the Hip.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]			[illegible]						
[illegible]	[illegible]					[illegible]					
[illegible]	[illegible]				[illegible]	No pain.	[illegible]		[illegible]		
	Tenderness [illegible]					No tender point.		Hyperæsthesia [illegible]		Never any point tenderness.	
	Resistance to passive motion [illegible]		No limitation of motion in all directions [illegible]	No limitation [illegible]	Motion free.	Usually free [illegible]	Motion [illegible] easily free.	Limitation [illegible]	No limitation of motion.	Resistance to motion in extension only.	Resistance [illegible] only in extension.
	Slight wasting of muscles. [illegible]					No atrophy.	Marked wasting of muscles.				
										[illegible]	[illegible]
	[illegible]	No [illegible]						[illegible]			
[illegible]		[illegible]									
[illegible]	Night cries.									[illegible]	[illegible]

joint or the epiphyses of the joint, is recognized by the fact that the inflammation invading certain groups of muscles causes a limitation to motion greater in one direction than in another, while the limitation to motion in disease of the joint is equal in all directions of normal motion of the joint.

Under the head of periarticular disease may be included inflammation of bursæ or of lymphatic glands, or psoas abscess, or psoas muscular spasm from caries of the lumbar spine (psoitis). This latter disease is not infrequently mistaken for hip disease. A careful examination of the muscular spasm aids the diagnosis. The diagnosis between true and neuromimetic affections of the hip is at times difficult. In a functional (hysterical) trouble there is a predominance of subjective symptoms of pain, sensitiveness, etc., and an absence or relative insignificance of the objective symptoms of muscular atrophy, characteristic attitude, and distortion. The stiffness on passive motion of the hip is much greater than would be usual in an early stage of hip disease, and out of proportion to the amount of unconscious active voluntary motion.

It has been supposed that an anæsthetic will be an aid in the diagnosis of hysterical coxalgia, as the muscular spasm of both hysterical contraction and of true hip disease disappears at an early stage of the affection under an anæsthetic, and, in a later stage, after the muscles have become permanently shortened, some contraction remains in spite of an anæsthetic. It is true, however, that there is much less stiffness under an anæsthetic in neuromimetic coxalgia of long duration than in true hip disease with active inflammation and osseous changes; but the latter can ordinarily be recognized without difficulty.

A separation of the epiphysis of the femur at the hip needs here scarcely more than mention, it is a rare accident occurring only before puberty, and the symptoms are those of intercapsular fracture of the neck of the femur, except crepitus is not present, or is slight and cartilaginous.

Separation of the epiphysis from the diaphysis may occur in juxta-epiphyseal osteitis, *i.e.*, in hip disease. It would be recognized by the fact that the trochanter has suddenly become much higher on the affected side than on the normal.

The rare accident of partial rupture of the adductor muscles of the thigh need not be mistaken for hip disease. Although there is flexion of the thigh and adduction, and muscular stiffness less than is normal, yet the absolute limitation to motion is chiefly from the remaining fibres of the injured muscles, which are spasmodically contracted to prevent the torn fibres from being stretched—which is not the case in true hip disease.

Congenital dislocation of the hip-joint need not be mistaken for hip disease, as the clinical history of the former is one of continued limp since the child commenced to walk, while in hip disease the limping is not congenital. There are also no symptoms of muscular stiffness or limitation of motion of the hip in congenital dislocation—in fact no symptoms of hip disease except the limp.

The same may be said of shortening of the limb from retarded growth.[106]

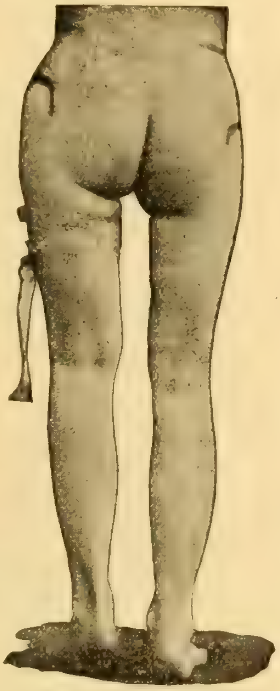
Fig. 4937.—Shortening in Congenital Dislocation of the Hip. (From a photograph.)

It is important, in an examination for hip disease, to determine the amount of permanent injury which the disease has already inflicted. The amount of enlargement of the acetabulum and absorption of the head of the femur which has taken place, may be estimated by determining the amount of subluxation. If the patient lie upon the well side, and a line be drawn over the suspected hip (the thigh being somewhat flexed), from the anterior superior spine to the most prominent part of the tuberosity of the ischium, it should pass just above the upper margin of the trochanter; if the trochanter is above this line, it is an evidence of subluxation.

The amount of abduction or adduction should also be determined. This can be calculated by means of degrees on the arc of a circle designed for the purpose; a more ready way is, however, furnished by means of the following table. The patient should lie straight on a table with the legs parallel. Real bone shortening should be estimated by a tape measure, and apparent shortening should also be estimated (by measuring from the umbilicus to each malleolus). If the apparent shortening is greater than the real, *adduction of the diseased limb is present*; if it is less, *abduction is present.* To estimate the amount of either present, measure from one anterior superior iliac spine to the other, and estimate in inches the difference between the real and the apparent shortening. Consult the table, and where the two columns opposite each of these figures intersect will be found the angle of the deformity.[107]

Table I.

Difference in inches between Real and Apparent Shortening.	Distance between Anterior Superior Spines in Inches.																	
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	..	..	..	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	..	..	..	..	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

In a similar way the flexion of the thigh may be estimated as follows:[108]

Lay the patient on his back on a table or any flat surface, and then raise the diseased leg by the heel until the lumbar vertebræ touch the table. Having placed the child in this position, measure off two feet on the external aspect of the leg with a tape measure with the zero of the tape on the table at A, and note the point B; from here measure the perpendicular distance in inches to the table C. Consult Table I., and opposite the number of inches found by measuring B C, will be found the number of degrees representing the flexion of the diseased leg from the normal position.

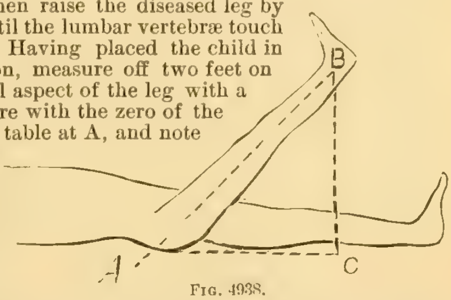

Fig. 4938.

Table II.

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	39	18.0	48	24.0	90

If the leg is so short that it is impracticable to measure off twenty-four inches, we can measure to a point on the leg distant twelve inches, from the table; ascertain the distance to the table in a perpendicular line just as before, double this distance, and look in the table as before.

A recognition of the existence of an abscess in the vicinity of the hip-joint is to be made by palpation. In acetabular hip disease, examination of the rectum will often reveal the presence of an abscess projecting into the pelvic cavity.

II. *Synovitis of the Hip-joint.*—Serous Synovitis of the hip-joint is not common. The existence of chronic tuberculous synovitis of the hip joint has been questioned, but there seems to be no reason why such an affection may not well exist and escape detection, for the opportunity for post-mortem examination does not occur until after the disease has involved the whole joint.

Chronic synovitis of the hip joint not extending to the bone is an uncommon affection. In a majority of cases, its existence must be an inference rather than a positive diagnosis. The writer has had under observation five cases with the usual symptoms of hip disease at an early stage, viz., limping gait, muscular atrophy, stiffness, limitation of motion at the joint, peculiar and characteristic attitude and slight pain persisting for months, and yet complete recovery took place. In one, death occurred from intercurrent disease six months later, and the remains of a synovitis in thickening and congestion of a part of the synovial membrane were found.

The course of acute, subacute, or chronic synovitis of the hip joint (if limited to the synovial membrane and not extending to the cartilage or bone) is not as protracted as that of epiphyseal osteitis.

Synovitis of the hip joint from traumatism may occur in sprains and contusions; the extent and course of such synovitis depend upon the nature and amount of the injury. In patients with tubercular predisposition, such injuries may produce tubercular disease. In certain cases, a synovitis of this sort passes away without permanent injury; in other cases, permanent disease or ankylosis results.

III. *Chronic Rheumatoid Arthritis of the Hip-joint*—morbus coxæ senilis, chronic rheumatoid arthritis—occurs chiefly in people of middle age or older; it may be limited to the hip, constituting morbus coxæ senilis, or may be combined with affections of other joints. The symptoms met are those already mentioned as encountered in an early stage of hip disease. The disease never leads to suppuration, but may to deformity and painful locomotion. In the lightest forms the disease may be a self-limited one, disappearing after a short subacute attack; but ordinarily, the course is long and frequently a permanent disability of the limb is left.*

Loose Cartilages in the hip joint are so exceptional as to be simply anatomical curiosities.

KNEE-JOINT.—The common chronic affections of the knee joint are the following: 1. Chronic synovitis with or without effusion; 2. hydrops articuli; 3. epiphyseal osteitis; 4. chronic rheumatoid arthritis. Besides these primary disease of the cartilage may occur. Displacement of the menisci, loose bodies in the joint, may give rise to joint inflammation. Charcot's disease is not uncommon in tabes dorsalis. Cysts connected with the knee joint should be also mentioned.

The knee joint deserves especial notice inasmuch as it is the largest and most exposed joint in the body, and the one most frequently attacked, if we may consider Schüller's figures (referred to above) as representative.

Anatomically, it should be noted that the joint surfaces forming it are nearly flat, and the facets in the tibia shallow. Owing to this fact the tibia is easily drawn backward and flexed by the hamstring muscles, the flexors of the leg being much stronger than the extensors, and also rotated outward, constituting the common and troublesome deformity which is the characteristic one after tumor albus, the result of the persistent muscular spasm. Certain cases of "internal derangement," as Hey called it, of the knee joint (and sometimes of others as well) have been reported since his original paper in 1803. The cause seems to be in certain cases the traumatic tearing away of one of the semilunar cartilages from its marginal attachments, and from having thus become able to slip backward or inward, it does so in certain movements of the joint, getting behind the condyle or into the intercondyloid notch, and giving rise to the symptoms described in the clinical history.

In other cases, owing to repeated attacks of synovitis, the attachments of the semilunar cartilages become loosened, and, allowing the cartilages to slip, cause the same symptoms.

Mr. Bradhurst reported a case where a laceration of the cartilage took place, and a piece of cartilage loosely attached caused the same sort of symptoms.

Dislocations of the semilunar cartilages are not uncommon.

The knee is the joint which is by far the oftenest affected by "internal derangement," but cases of it in the elbow and temporo-maxillary joint are on record.

Chronic Synovitis.—Simple chronic serous synovitis is often the sequel of the acute or subacute form. It may be rheumatic in origin, or possibly due to exposure to wet or cold. It occurs at any age, either in children or adults, generally under forty. It may occur at any time after an injury or strain. The earliest symptoms are usually impaired motion and pain; occasionally a loss of strength is complained of. The pain is not severe unless the joint is excessively used, and it is relieved by rest. Later, swelling, increased surface temperature, and redness of the skin appear. Tenderness may not be marked, except in the acute stages. If neglected, acute inflammation, even of a purulent type, may result. There may be moderate muscular atrophy. After a time, in some cases, the swelling slowly disappears with the absorption of the effusion. The patient no longer has pain or tenderness. The mobility of the joint is restored. In many cases this recovery is not permanent, for after a period of weeks or months a recurrence of the attack occurs, and ultimate recovery only follows after several such exacerbations. Generally, where no constitutional tendency to disease exists to change the character of the affection, the joint finally becomes normal.

Chronic synovitis presents itself in various forms. There may or may not be effusion; the effusion may be serous, sero-purulent, or completely purulent, according to the violence of the affection.

In tubercular synovitis suppuration is almost certain to occur, with thickening of the synovial, subsynovial, or periarticular tissues and the formation of abscess with spontaneous opening and the development of sinuses. The disease (tubercular synovitis) usually extends to the cartilage and bone, giving rise to a train of symptoms analogous to those to be observed in chronic epiphyseal osteitis.

Synovitis of the knee joint may, however, remain indefinitely in a subacute condition, with a slight amount of effusion and accompanied by thickening of the synovial membrane, which sometimes is gelatinous in appearance. A large amount of serous effusion may take place, with slight inflammatory symptoms, and the affection may resemble, clinically, the simple non-inflammatory effusion termed "water on the knee."

The clinical course of chronic synovitis necessarily varies as it does pathologically. It may be the result of an acute attack, or it may more commonly begin insidiously, the patient complaining at first of an impairment of strength and slight pain; presently there is a limping gait, with slight tenderness on pressure at the knee, usually over the inner condyle; impairment of motion at the knee is to be noticed; the limb is slightly flexed at the knee, and there is usually swelling apparent at the knee, to be demonstrated by measurement. Muscular atrophy of the muscles of the thigh and calf occurs, and the disease may progress gradually to complete stiffness, or there may be an intercurrent attack of acute synovitis with attendant exacerbation of symptoms.

Hydrops articuli differs clinically from the ordinary type of synovitis in that there is rarely any pain; the symptoms may develop gradually, there being no complaint except a slight, hardly noticeable one of loss of strength. The characteristic effusion gradually develops, disappearing slowly, or remaining for a long time unchanged. Sometimes, however, the effusion appears without premonition and disappears equally rapidly.

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* For a case of [illegible] of the hip [illegible] in the Boston Medical and Surgical Journal, November 15, [illegible].

Muscular atrophy, impairment of motion, pain or tenderness, may all be absent, there being no evidence of trouble except the effusion in the joint.

Epiphyseal Osteitis. The commonest affection of the knee in children is the classical "white swelling" of the older writers. It may be either a diffuse osteitis or one limited to certain portions of the epiphysis, and the femoral or tibial epiphyses are attacked with equal frequency. In rare instances the patella has been primarily attacked.

Epiphyseal osteitis of the knee-joint begins, as a rule, insidiously, with stiffness and limp in gait. The disease may be limited for years, and be displayed by an enlargement of the condyles or head of the tibia, or it may extend and involve the whole joint; occasioning severe pain, swelling of the periarticular tissues, effusion in the joint, periarticular abscess, distortion of the limb, *i.e.*, flexion and subluxation; and ending in a natural cure with fibrous or bony anchylosis and a distorted limb, which may be more or less serviceable, according to the distortion; or the affection may result in so extensive suppuration as to endanger life from septic or amyloid changes. Sometimes an attack of severe pains supervenes, representing an acute stage, and the limb is flexed at the knee, hot and tender to the touch, and sensitive to any jar. This stage gradually subsides, and there is left impairment of motion, if not complete stiffness. Characteristic of chronic epiphysitis of the knee, if it persists for any length of time, is enlargement of the bone.

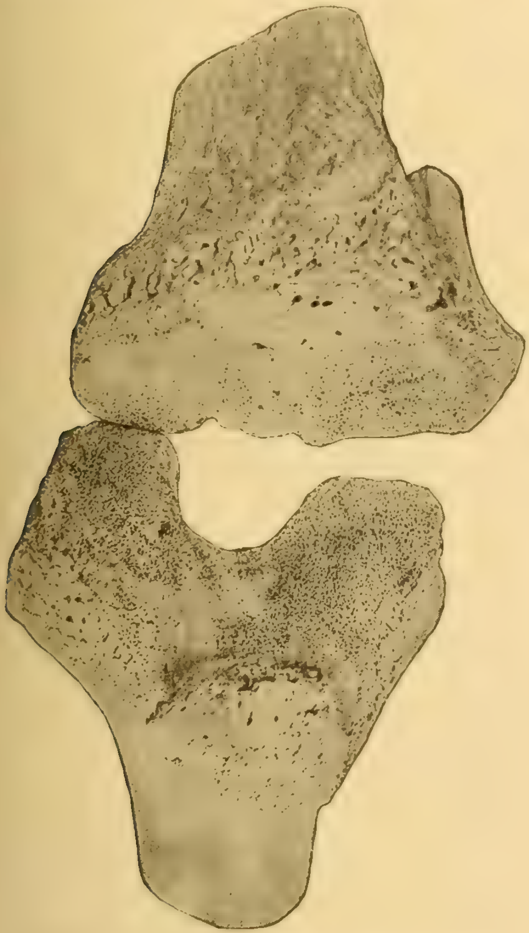

Fig. 4939.—Erosion of the Cartilages in Knee-joint Disease.

In some instances, one of the condyles is enlarged more than the other—usually the internal condyle—causing knock-knee. In the severer cases, suppuration follows, with the establishment of sinuses. The disease progresses to a cure with a stiffened limb, or the destructive process may become so extensive that excision or amputation is required.

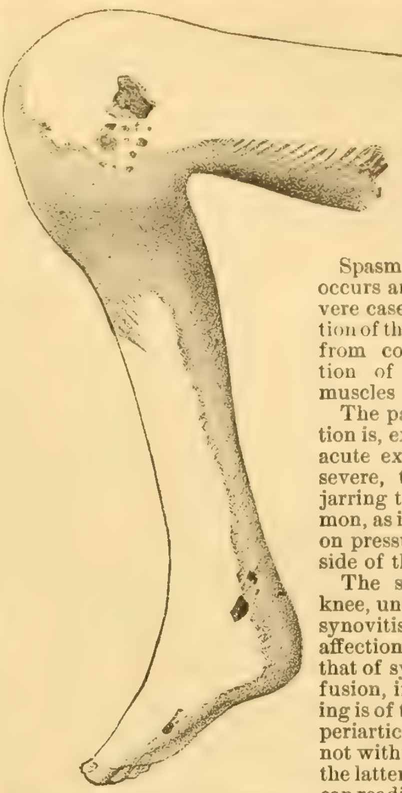

Fig. 4940.—Subluxation in Knee-joint Disease. (Schreiber.)

Muscular atrophy invariably occurs.

Spasm of the muscles occurs and results, in severe cases, in a subluxation of the tibia backward from constant contraction of the hamstring muscles (Fig. 4940).

The pain of the affection is, except during the acute exacerbations, not severe, though pain on jarring the limb is common, as is also tenderness on pressure at the inner side of the knee.

The swelling at the knee, unless suppurative synovitis be added to the affection, differs from that of synovitis with effusion, in that the swelling is of the bone and soft periarticular tissues, and not within the joint. In the latter case fluctuation can readily be determined by palpating on both sides of the patella, the limb being so placed that the quadriceps extensor muscle is reflexed. If the effusion is large, as in chronic serous synovitis, the patella, when the muscles holding it are relaxed, can be depressed on pressing on it, as it floats above the fluid within the joint. In effusion the shape of the swelling is characteristic. It is most prominent on both sides of the patella, being limited by the tendon of the quadriceps extensor muscle and by the ligamentum patellæ.

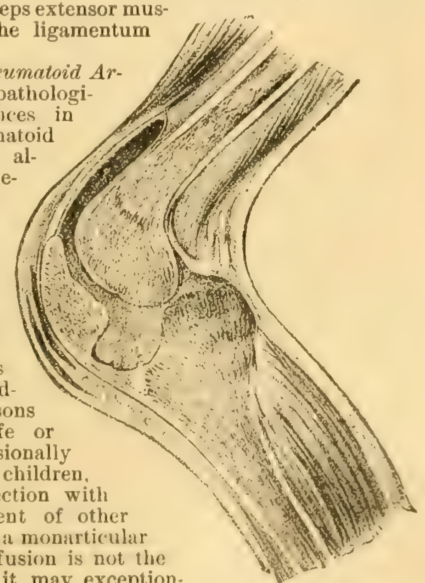

Fig. 4941.—Subluxation of Knee. Cross Section. (Schreiber.)

Chronic Rheumatoid Arthritis.—The pathological appearances in chronic rheumatoid arthritis have already been described. They are found more characteristically developed in the knee than in any other joint. The disease always develops gradually in persons of middle life or older. Occasionally it is seen in children, but in connection with the involvement of other joints, not as a monarticular affection. Effusion is not the rule, though it may exceptionally occur. Enlargement of the joint is almost constant. The symptoms are rarely acute, the most marked being a limping in gait, a sense of stiffness, especially after sitting for some time, limited motion, and eventually an irregular enlargement in the contour of the joint. The pain present is usually caused by motion or jar, and is absent when the joint is at rest.

The disease is chronic, and not subject to acute exacerbations.

It sometimes produces complete disability from contraction of the limbs, which are often strongly flexed.

The affection of the knee occurring in tabes dorsalis clinically differs from chronic rheumatic arthritis but little, except that the disease is often much more destructive, causing complete disability with practical destruction of the joint.

Diagnosis.—A diagnosis of affections of the knee joint is based on limp in gait, stiffness, change in contour of the joint, pain, tenderness; the prominence of these symptoms being dependent upon the activity of the affection. Limping may be considered a constant symptom, although in the mildest cases of hydrops articuli it is slight. The same may be said of limitation of motion at the knee. Pain or tenderness are not constant symptoms in the earlier stages and milder forms of affections at the knee.

Differential Diagnosis.—Gross errors in diagnosis in affections of the knee are not common, as a thorough examination of the joint is readily made. The distinction between a synovitis with effusion and a chronic ostitis, is based on the size and shape of the swelling. A diagnosis between a subacute synovitis without effusion and an epiphyseal ostitis, at an early stage, is difficult or impossible. It should be borne in mind, however, that in a pure synovitis there is thickening of the synovial membrane without enlargement of the bone, and in pure epiphysitis the reverse is true if the epiphysitis is well developed.

Periarticular disease (inflammation of bursæ, periarticular abscesses) is to be distinguished from true articular disease in that there is little or no stiffness, and the swelling, if present, does not bear the relation to the patella that occurs when there is fluid beneath the patella.

Functional disease (hysterical, neuromimetic) of the knee is to be recognized by the absence of objective symptoms, and the prominence of subjective symptoms.

Diagnostic Symptoms in Chronic Diseases of the Knee.

Symptom.	Hydrops.	Epiphyseal ostitis.	Periarticular inflammation.
[illegible]	No pain or tenderness.	[illegible]	Tenderness. Some pain on forced flexion.
[illegible]	[illegible]	[illegible]	Little or no limitation of motion.
[illegible]	[illegible]	[illegible]	[illegible]
Limp.	No limp.	Marked limp.	May be some limp if extensive [illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Loose Bodies.—The knee joint is the favorite seat for the cartilaginous bodies known as loose bodies, or floating cartilages. These vary in size and in number, being sometimes found in very large numbers. Billroth mentions one as large as the patella; ordinarily they are comparatively small.

They occasion suffering by becoming occasionally caught between the femur and the tibia, and occasionally they give rise to an attack of synovitis with effusion. These attacks vary in frequency. The pain is sometimes quite severe and the disability complete. It is relieved when the cartilage is freed from the position in which it has been caught, which will happen often after a slight twist of the limb which the patient learns by experience how to perform.

Ordinarily the trouble is only a transitory one, not recurring frequently, but in severe cases it may cause great disability from frequent recurrence.

Loose cartilages can sometimes be felt on palpating the joint.

Disease of the Menisci.—A few cases have been reported of primary disease of the semilunar cartilages, the disease was, however, only demonstrated after opening the joint.

Displacement of the Semilunar Cartilages.—Displacement of the menisci, though not a usual affection, may occur, and give rise to severe pain and synovial effusion. This is probably the cause of the obscure trouble which has been described as an "internal derangement of the knee joint." The symptoms resemble those occasionally seen following loose cartilages, viz., sudden severe pain, inability to use the limb, and often a troublesome synovitis.

Hey describes the affection of "internal derangement" of the knee as due to some alteration "which prevents the condyles of the femur from moving freely in the hollow formed by the semilunar cartilages, and articular depressions of the tibia. An unequal tension of the lateral or cross ligaments of the joint or some slight derangement of the semilunar cartilage," may explain the symptoms.

This affection has become more common since the prevalence of lawn tennis as a sport.

Cysts of the Joint.—Synovial cysts may be formed about the knee-joint as about other joints; they may enlarge and produce an unusual appearance in the shape of the joint. In many instances they are connected with the joint by a small opening; a common place for such cysts is in the popliteal space.

It should be remembered that a number of bursæ are to be found about the knee joint, and may become enlarged.

Slipping of the Patella.—Slipping of the patella to the side sometimes occurs as a sequela of a laxity of the ligaments about the capsule of the knee-joint, and a loss of tension of the quadriceps extensor muscle.

It is an annoying rather than a painful affection, though it may at times cause a synovitis.

ANKLE-JOINT.—The diseases of the ankle joints are either synovitis, ostitis, or the affections chiefly periarticular, involving the tissues about the joint, tendons, bursæ, etc.

Simple synovitis of the ankle-joint is not common. When it is present it is usually the result of injury. Owing to the anatomical relations of the parts, serous or purulent effusion can take place only to a limited extent. Periarticular swelling is a marked and early symptom,

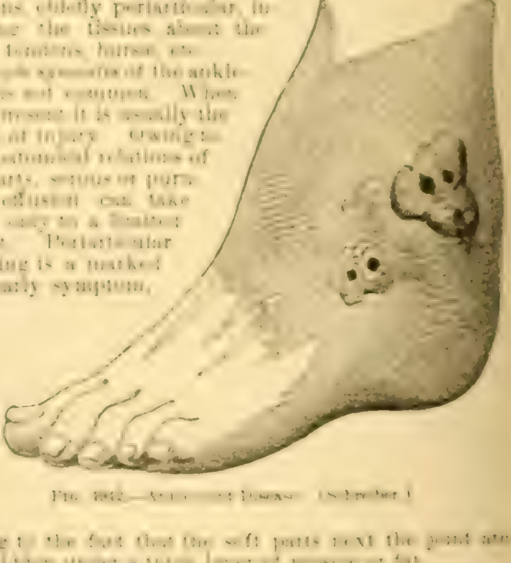

FIG. [illegible].—Ankle-joint Disease. (Schreiber.)

owing to the fact that the soft parts next the joint are not hidden under a thick layer of muscle or fat.

Pain on motion occurs prominently in acute synovitis.

but in chronic synovitis a certain amount of motion is possible without pain, but the motion of the joint is limited.

Swelling or puffiness of the tissues in front and behind the malleoli is to be noticed (Fig. 4942), and sometimes tenderness on pressure.

Chronic fungous synovitis may exist, but if it persists a long time, it extends to the cartilage and bone.

Osteitis.—In patients with tubercular diathesis, slight injury to the foot may develop an osteitis, either of the astragalus or of the lower end of the tibia. This may come from an extension of the disease from the synovial membrane, or it may originate in the bone; other adjacent bones may become involved, as the os calcis, and scaphoid, cuboid, or cuneiform bones.

The affection is usually painless, except where a large periarticular abscess has been developed; it is characterized by limping, a limitation to the motion of the joint, and a swelling of the ankle; this swelling is uniform around the ankle, except where an abscess is pointing on one side. The depressions in the contour of the ankle in front and behind the malleoli disappear in the swelling, and the foot is extended and slightly abducted. Some weight can be borne on the limb in the early stages, but if the disease becomes extensive the limb cannot be used to bear weight. The foot in affections of the ankle-joint usually assumes a position with the toes pointing downward, and in chronic cases with the foot slightly rolled outward (in the position of equino-valgus).

Chronic rheumatic arthritis rarely affects the ankle-joint.

Diagnosis.—The recognition of disease of the ankle is dependent on the usual symptoms of limping, limitation of motion of the joint, stiffness, swelling of the limb, pain, and tenderness. The prominence of these symptoms varies with the activity and extent of the disease.

Teno-synovitis gives rise to swelling around the tendons affected in functional, neuromimetic, or hysterical affection of the joint; there may be some puffiness of the skin, heat, hyperæsthesia and pain on movement of the foot; but extreme change in contour of the ankle is not present, and the pain is chiefly that of apprehension. A functional affection of the joint may result from sprains and fractures if treated too long by fixation. A diagnosis between synovitis without effusion and osteitis is not easily made, and is not necessary for treatment. Effusion is recognized by palpation of the parts of the ankle where the synovial capsule can be distended, that is, in front and behind the malleoli, and on both sides of the tendo Achillis and of the tendons in the front of the foot.

Periarticular disease is to be recognized by the localization of the tenderness, which is not to be found uniformly over the region of the most exposed portion of the joint, and by the fact that swelling, if present, is not uniformly diffused around the ankle.

A localization of the situation of the osteitis, *i.e.*, whether it is in the articular end of the tibia or tibial surface of the astragalus, is not possible, but in the earlier stages it is possible to recognize the fact if the disease is limited to the anterior surface of the astragalus (the portion articulating with the scaphoid), from the fact that in the latter case the motion at the tibio-astragaloid articulation is free. This is certainly the case where the os calcis alone is involved.

In cases of osteitis in the distal part of the foot the swelling when present involves this part of the foot entirely, or to a greater extent than the ankle.

SCAPHO-CUNEIFORM ARTICULATION. — Erichsen and Gosselin have described a rare affection of this complicated articulation. Motion at the ankle is free, but weight cannot be borne in severe cases by the foot. At a later stage the front of the foot becomes swollen.[113]

METATARSO-PHALANGEAL ARTICULATIONS. — These joints are occasionally attacked as a result of injury. In chronic rheumatoid arthritis they may also be attacked. Inflammation of the metatarso-phalangeal articulation of the great toe takes place as a result of the distortion of the toe called "hallux valgus," or in-toe, the result of imperfect shoeing, and also secondarily to the affection commonly known as bunion. A chronic rheumatoid arthritis of the joint is common, and it is a favorite seat for gout. An anchylosis of this joint occurs in adolescents, probably a sequela to a long-continued subacute inflammation. Nothing especial need be said of inflammation of the phalangeal articulations, except that they are not common.

SHOULDER-JOINT. — *Chronic serous synovitis* of the shoulder is a rare affection, most frequently met with in young children, either as a sequel of an acute attack, or as a slow, persistent process, beginning with slight symptoms easily disregarded.

Pain is either absent, or so slight as to often escape attention. The earliest symptom to attract notice is stiffness, observed particularly in forced movements, as in placing the hand on the head, etc. A slight fulness about the joint may be detected at this time, the humero-pectoral groove being indistinct, and the depression below the acromian obliterated. Although an increase of surface temperature may often be detected, its absence is of little importance, the joint being so thoroughly covered. As the disease progresses the case presents an exaggeration of the early symptoms, motion becomes more restricted, swelling increases as effusion takes place, the shoulder appearing broader, and elevations replacing the natural depressions. Atrophy of the deltoid and scapular muscles gradually occurs, but to a less extent than in the forms of osteitis.

As the joint is easily kept quiet, the symptoms gradually subside after several months, and the person recovers with a stiff joint.

Purulent synovitis may follow acute, subacute, and chronic synovitis, or develop in septic or pyæmic conditions.

Duplay has described as *periarthritis* of the shoulder-joint a condition of stiffness not infrequently seen after comparatively slight injuries. Pain accompanies motion beyond a certain limit. The amount of articular motion is apparently greater than is actually possible, owing to the mobility of the scapula, which moves with the humerus. Raising the arm above the level of the clavicle is difficult, as well as turning the arm behind the back. Atrophy of the muscles is present, and at times some spontaneous pain. The arm becomes of comparatively little use.

The diagnosis of periarthritis is not based on pathological evidence, and, judging from clinical analogy, it seems fair to infer that the affection may include the synovial membrane, constituting a chronic synovitis as well as a periarthritis.

Osteitis.—The general symptoms of osteitis of the shoulder differ in no way from those in the usual form of this disease in other more commonly affected joints; but stiffness at the joint is less noticeable on account of mobility of the scapula. The disease is insidious, extremely chronic, and prone to suppuration, and decided impairment of the joint is certain to result. Young children are most frequently the subjects, but adults are not exempt.

The forms of osteitis of the shoulder, whether beginning in the epiphysis or in the articular surfaces, or secondary to synovial disease, undoubtedly present more or less characteristic symptoms, but information is not at present sufficient to make definite distinctions easy. The more common varieties of this disease begin as an epiphysitis, or as a fungous synovitis. The history of a preceding injury is frequently obtained, but is by no means a necessary factor in a typical case. The earliest sign of this disease is pain, of a dull aching character, which is usually aggravated at night, and is referred either to the joint itself, or to the middle of the arm near the insertion of the deltoid. In many cases this symptom is absent, or very slight, and probably in these the origin of the disease is in the synovial membrane. About this time the child is noticed to use the arm much less, and upon examination a certain amount of stiffness is found. A slight increase of surface temperature may be detected, but the thickness of the coverings of the shoulder-joint renders this uncertain. The deltoid and scapular muscles early show signs of atrophy, even at this stage. There will usually be found a tenderness, frequently localized over a small area, and it is often a prominent symptom, especially in epiphyseal disease. The patient instinctively holds the arm at rest, and any attempt at passive motion provokes muscular spasm, and if this attempt be persisted in, the humerus and scapula are seen to move together.

Early in the disease a change in contour of the joint becomes apparent, and is due to enlargement of the head of the humerus as well as to muscular atrophy. This enlargement may not be symmetrical, perhaps more often presenting a localized swelling representing the situation of the disease.

The course of the disease is slow, the early symptoms, which were perhaps slight, become more pronounced; this is particularly true of the swelling and stiffness. The amount and character of the swelling depend upon the course of the disease. The stiffness may increase to complete, or almost complete, loss of motion of the humerus on the scapula. When the swelling is due to effusion within the joint, the shoulder appears fuller and rounder than normal; it is seen best by looking down on the patient; and the natural depressions in front and behind the joint become either obliterated or the sites of prominences.

In the epiphyseal form of the disease, suppuration is the rule, but it is not common in the other forms. The subsequent history depends on this result. When suppuration does not occur the symptoms gradually subside, the swelling disappears, and recovery takes place after several months, leaving a stiff joint.

If suppuration occurs, the patient complains more of pain, and the swelling increases. The prominence of the swelling will depend on the direction taken by the pus, but will be found collected in the axilla, under the deltoid, or along its anterior edge. When the pus breaks through into the cavity of the joint, the ordinary signs of a purulent synovitis supervene. The subsequent course is slow, the result depending on the extent of the carious process, which may terminate soon after evacuation of the pus, or continue to complete destruction of the head of the humerus.

The possible results are: recovery with a simple stiff joint; anchylosis, deformity, and impaired muscular power; entire destruction of the head of the bone; later, arrest of development of the humerus.

Chronic Rheumatic Arthritis of Shoulder.—Next to the knee the shoulder is the most frequent seat of this disease, which appears usually after the middle period of life.

Frequently there will be the previous or hereditary history of rheumatic tendency, but again, nothing of the kind can be traced. When one shoulder alone is affected a history of injury is the rule, but in the polyarticular forms this is not to be expected.

The disease may first manifest itself to the patient as a slight attack of joint pain, tenderness, and stiffness, and from this condition pass into the slow chronic course, with occasional exacerbations; or it may begin insidiously. The amount of pain varies, is more or less persistent, but not constant, and is dull and heavy, usually worse at night. Stiffness appears at this time with the pain; at first it is only slight, and is noticed in forced movements, as when the arm is raised above the level of the shoulder. Both pain and stiffness are more noticeable after a period of rest.

From the appearance of these symptoms the progress of the disease is slow, extending over months before marked change occurs. As the disease advances the muscles waste, and, in severe cases, to a very marked degree.

A creaking or crackling sensation on both active and passive motion is almost always found. It is best detected by placing the hand over the joint. The amount of this varies considerably in different cases, but does not seem to have any definite relation to the prominence of the subjective symptoms.

Later in the disease, when the characteristic osseous changes occur, the arm can be raised but a short distance from the side, and the loss of muscular power is very great. Swelling independent of bone enlargement sometimes occurs, and is due to effusion within the cavities of the synovial membrane, but is not a common occurrence, and usually appears late in the disease.

When these changes have taken place, a characteristic appearance of the joint is found. The head of the humerus is more prominent in front of the joint, while behind is a depression as if the head of the bone was displaced forward, while the shoulder droops, this being due both to ligamentous changes and loss of muscular tone.

Among the results which may occur from the change in the bone, is separation of the acromion, and displacement of the long head of the biceps from its groove, and its subsequent rupture.

The shoulder is not infrequently the seat of neural arthritis, that of Charcot's disease, but differs in no way in the course and symptoms from the same in the more commonly affected joints.

ELBOW JOINT.—A subacute synovitis of the elbow is not an uncommon occurrence after a blow or sprain. The symptoms are pain, swelling from the effusion within the joint, and stiffness. The disease continues several weeks or months, and may gradually subside, but is liable to leave considerable impairment of motion.

Purulent synovitis may appear in this as in other joints, from the usual exciting causes.

An ostitis frequently follows an injury to the joint, but in many cases appears with no apparent cause. It usually occurs in young children.

The disease may begin with pain, but this is not severe, and often is entirely absent. Limitation of extension of the forearm is a constant and early symptom, motion in this direction being distinctly restricted when flexion, pronation, and supination are free. A slight increase of surface temperature is usually found, but its absence does not exclude the disease.

Careful examination will reveal a slight amount of swelling even at this stage of the disease, shown by fulness and thickening on either side of the triceps; and, looking at the elbow from behind, the joint appears broader than normal. As in other joints, wasting of muscles occurs rapidly, and in severe forms of the disease is very great, especially on the forearm.

As the disease progresses the stiffness increases, motion in other directions is restricted and resisted by muscular spasm, and the joint is held at an angle of about 140°. Starting pains may be added to the other symptoms, and become the source of great discomfort. The whole joint becomes involved in the swelling, the enlargement assuming a fusiform shape, and displaying a greater prominence on the lower radial side of the joint. As the cartilages disappear, and the carious process in the articular extremities of the bone becomes established, the signs of abscess soon appear.

Chronic rheumatic arthritis of the elbow, in its course and symptoms, presents no difference from the same disease in the shoulder.

It is, however, a less frequent seat of the disease, and is one of the joints least liable to be affected alone. The position assumed is flexion.

Urethral arthritis is very prone to be located in the elbow, in this respect, perhaps, ranking second to knee only. A stiff joint, held in flexion, is the usual result.

WRIST JOINT.—Ostitis of the bones of the wrist occurs not infrequently as the result of injury by blow or sprain, and as a secondary affection to disease of the synovial membrane, or primarily from tubercular disease. Its onset is usually so insidious that the presence of the disease is often not suspected until considerably advanced. In other cases a slight amount of pain may call attention to the part, or some peculiarity in the manner of using the hand is observed. Examination will reveal a limitation to full extension. Other motions may be perfect. Wasting of the muscles of the arm will also be found.

If the disease is further advanced, deformity and swelling will be added to the other signs. The hand is held flexed on the forearm at an angle of one hundred and twenty to one hundred and thirty degrees. Swelling appears first in the depressions between the tendons. Later, measurement will show the joint to have increased in circumference, and there is a fulness of outline especially on the dorsal surface, and in destructive disease the swelling extends up on the forearm and down on the hand. Suppuration is very liable to occur, and the course of the disease is usually long and slow. Recovery may take place without suppuration having occurred, in which case the strength of the hand will suffer less. Flexion of the hand on the forearm is the usual position, and motion of the fingers is more or less interfered with.

Chronic Rheumatic Arthritis.—The wrist is a common seat of this affection, with the ordinary symptoms of pain, swelling, stiffness, creaking, etc. Weakness of the hand is frequently complained of. Stiffness is more marked in pronation and supination, motion in this direction being limited before flexion.

When deformity has occurred the wrist is generally flexed, and the distal ends of the radius and ulna are enlarged and project backward. Frequently the hand is adducted, this often being associated with a similar distortion of the fingers.

The wrist is one of the joints liable to the attacks of *urethral arthritis*. The joint is usually left flexed at about one hundred and thirty degrees, and considerable wasting of muscles of the forearm may remain.

Phalangeal Articulations.—Owing to their exposed position to sprains, blows, etc., the phalangeal joints are frequently found enlarged, slightly deformed, and stiff, extension being limited.

Chronic Rheumatic Arthritis.—The hand is a very common seat of this affection, the disease often beginning in one or two joints of one finger, and some time elapsing before others are attacked. The joints become much enlarged, and distortion usually occurs to the ulnar side, this adduction being chiefly in the metacarpo-phalangeal joint.

The fingers remain permanently distorted, becoming flexed or adducted or both; the second phalanges of the fingers, as well as of the thumb, are usually extended, giving a characteristic appearance to the hand.

Sterno-clavicular and Acromio-clavicular Joints.—Enlargement of these joints sometimes occurs in persons accustomed to hard work with their upper extremities. Inflammation of the sterno-clavicular articulation, followed by suppuration and caries, is occasionally observed, but it presents no unusual symptoms. Chronic rheumatic arthritis may occur in either of these joints, causing pain and stiffness, enlargement, and weakness of the upper extremity. The sterno-clavicular joint is not an infrequent seat of urethral arthritis.

Articulation of the First and Second Pieces of the Sternum.—Disease in this situation is rare, but has been described by Mr. Hilton. Symptoms were, pain about the sternum especially severe on forced or sudden respiratory exertion, and great tenderness over the joint. Recovery took place.

Temporo-maxillary Articulation.—By far the most common affection is chronic rheumatic arthritis; other diseases are rare.

Tuberculous disease may occur, secondary to disease of the ramus or ear.

Subluxation occurs from relaxation of the ligaments, usually in young people—frequently in women. The patient suddenly finds himself unable to close the mouth. If unilateral deviation from the median line be present, the jaw is unduly prominent. A tendency to this accident, once established, is usually permanent.

Chronic Rheumatic Arthritis.—Females are more prone to these affections than males, and young feeble subjects as well as old. One or both sides may be the seat of the disease. The usual symptoms of pain, stiffness, crackling, are present. There may be some general fulness about the joint, but deformity rarely occurs; local tenderness on pressure also occurs sometimes. A sensation of grating is sometimes complained of by patients. In extreme cases anchylosis is reported to result.

Vertebral Articulations.—French writers have described an acute or subacute inflammation of the vertebral articulations, but the affection must be an uncommon one. Inflammation of the vertebral articulations occurs in the course of gonorrhœal rheumatism. Chronic rheumatic arthritis of the vertebral articulations has been described by writers on the subject, particularly by Adams.[114] Rosenthal[115] mentions cases where peripheral neuralgic pains are apparently dependent on nerve-pressure consequent on rheumatoid alterations in the vertebral articulations. There is marked stiffness in the motions of the spine. Complete anchylosis of the spine may result, and accompanying this is usually to be found an anchylosis or limited motion at the articulations of the ribs with the vertebræ.[116]

Sacro-iliac Articulation.—For a consideration of disease of this joint the reader is referred to the article on the subject in Volume VI.

Symphysis Pubis.—Inflammation of this joint has been described. It occurs in pyæmia, and rarely idiopathically (see Holmes's "System of Surgery," Article, Diseases of Joints). A relaxation of this joint may occur in pregnancy.

Sacro-coccygeal Joints.—Inflammation of this articulation has been mentioned as following injury.

Treatment.—On the subject of treatment of chronic diseases of the joints, it may be said that in cases influenced by constitutional states constitutional treatment is manifestly indicated, and the reader is referred to the articles on Tuberculosis, Rheumatism, and Gout for details of appropriate medication. It is self-evident that the better the patient's health is, the better the patient's chances of recovery are, even in affections comparatively localized. In tuberculous joint affections the benefit of fresh air and exercise is particularly to be borne in mind.

The general methods for surgical and local treatment of chronic diseases of joints may be enumerated as follows: 1, local applications (counter-irritation, cauterization, inunctions, frictions, massage, subcutaneous injections); 2, compression; 3, fixation; 4, protection from jar; 5, distraction (extension). In addition to these the operative measures, aspiration, incision, excision, and amputation, are needed at times.

Local Applications.—The benefit to be derived from local applications comes chiefly from an alteration in the circulation of the parts and a relief of a condition of congestion, if such exist. Blisters, counter-irritation, and cauterization play less of a part in modern therapeutics than formerly, but in certain cases they appear to afford relief.

Friction and massage, in certain cases apparently, in improving the circulation, improve also the condition of the joint. It is probable that in this way galvanism is beneficial.

Ignipuncture in joint affections has been recently recommended by Kolomin, for epiphyseal osteitis, especially in the foot and wrist in children. In cases of chronic synovitis with absence of pain and tenderness, it is not recommended by the advocate of the method. An anæsthetic should be used, and a Paquelin cautery should be the instrument selected, and either superficial punctures, burning the soft infiltrated tissues round the joint can be used, or deep punctures extending to the bone and marrow, the latter after trephining the sound bone. Antiseptic dressings should be applied. Either a number of punctures can be made, or a few deep ones, according to the condition of the disease.[117] The method has also been used by Ollier, who divides the skin and sound tissues with a knife, and if necessary the bone should be exposed and thorough antiseptic cleansing should be carried out. Ollier and Vincent regard the method of more use in certain diffuse cases of tubercular epiphysitis than that by the curette.[118]

The benefit of inunctions is probably that of frictions generally, namely, the establishment of an improvement in circulation and the diminution of congestion. The application of moist heat, poultices, wet-pack, is often agreeable. And if there is inflammatory heat in the part, cold compresses, irrigation, or the ice-bag are advantageous; the cold douche or cold applied by means of Leiter's coil.

The subcutaneous injection of solutions of iodoform into tubercular granulation tissue has been recommended in fungous diseases of joints, but the results reported have not brought the method beyond the experimental stage.

In the view of imitating the spontaneous cure of fungous granulations in tuberculous joint disease by calcification, Kolischer has in a number of cases injected subcutaneously a concentrated solution of calcium phosphate at the seat of the disease. The solution is as follows: 75 grains of neutral phosphate of calcium are dissolved in twelve ounces of water, and enough phosphoric acid is added until a perfect solution is obtained. Nine minims of dilute phosphoric acid (Austrian Pharmacopœia) are added with 5 ounces more of water. The whole solution is sterilized by boiling and injected into the fungous tissue by means of a syringe with a platinum needle. The joint is dressed with gauze wet in a solution like the above, except that 90 minims more of dilute phosphoric acid should be added. There is a great deal of pain after the injection, and morphia is usually necessary. Fever and induration of the tissues follows. Kolischer and De Lone report successful cases.

The injection of solutions of iodine into the joint cavity is a remedy which was occasionally used in former times, but it fell into disuse.

Of late the irrigation of joints with aseptic solutions has been advised and practised. Solutions of carbolic acid, 1 to 20, or of corrosive sublimate, 1 to 1,000, are used. Hager reports the injection through a small trocar of such solutions with benefit in cases of relaxation of the shoulder and of the temporo-maxillary joint.

Compression.—Compression promotes absorption of fluid in œdematous tissues and effusion. It can most readily be applied to the knee by means of rubber bandages or other elastic compresses. Dried compressed sponges bandaged around a knee and then wet, will, by expansion, produce pressure in cases of chronic synovitis of the knee-joint or hydrops articuli, and are occasionally used. Elastic cloth or flannel bandages can be used, but sheet rubber bandages will be found best. In arranging compression, it is important that the pressure should be exerted chiefly on the synovial membrane and affected tissues, and not on the more prominent healthy parts of the bone. To arrange this rolls of cotton are sometimes needed, and the bandage is to be placed in the depressions of the joint, as at both sides of the patella or malleoli.

Fixation.—Fixation, *i.e.*, the prevention of motion at a joint, is indicated in all active inflammatory conditions of a joint. In subacute conditions of inflammation a limited amount of careful motion is not injurious, the amount of motion varying according to the state of the joint. Sudden, violent, or jerky motion is, however, injurious.

In cases of synovitis pure and simple there is manifestly greater indication for fixation than for protection, the reverse being true in epiphyseal osteitis. Passive motion, massage, active motion, and forcible motion of a joint all may be indicated in stages of convalescence, for the purpose of breaking up and stretching adhesions which glue the ends of the bones together or to diminish the thickening of the synovial membrane. Motion being a normal function of a joint, it is manifest that as much motion should be permitted as is compatible with the inflammatory state. The question when fixation should be interrupted and passive or active motion allowed, is one of judgment in each case. It should, however, be borne in mind that passive motion begun too early, or employed with too great force, is apt to increase the existing synovitis, and the ultimate recovery of the joint is retarded rather than hastened. It should also be remembered that the absence of pain or tenderness does not indicate the absence of osteitis and the safety of unprotected motion at a joint. Bone is not a sensitive structure, and there is comparatively little increase of sensitiveness accompanying a subacute localized osteitis. Verneuil has called attention to the danger of the frequent and early use of forcible passive motion, and has laid great stress on the undue fear of the formation of ankylosis (ankylophobia, as he terms it) from fixation of the limb. He claims that ankylosis results from inflammation, and that the best way to prevent ankylosis is to check inflammation, which is most readily done by rest and fixation. That ankylosis does not invariably take place simply from rest is shown by the fact that in the limbs of hemiplegics, where immobility is unavoidable, ankylosis does not result, except when chronic rheumatic arthritis is coexistent; but in the joints stiffness results after too long fixation in fractures, partly from traumatic inflammation, partly from periarticular contraction.

Passive motion is of more use in combating periarticular contractions than in cases of pure arthritis, and it is for the prevention of these chiefly that passive motion is advisable. But it is also true that motion is a normal function of a joint, and that its tissues are not in normal condition unless this function is brought into use.

Protection.—Protection from the jar incidental to locomotion is of importance in osteitis of the joints of the lower extremities, except in the latest stage of convalescence, and fixation, that is, prevention of flexion or extension, or the normal motion of the joint, is important in the acute stages of synovitis. The importance of protection is often overlooked in the supposition that if a knee or ankle is fixed by a stiff bandage, the patient can bear weight upon the limb, forgetting that the accidental jar to the inflamed epiphyses is more injurious even than motion. The simplest method of protection in affections of the lower extremity is by the use of crutches, but, as will be seen under the headings of individual joints, other more convenient means can be used. Protection from jar in joints of the upper extremity is readily effected by the means used for fixation.

Distraction.—The "distraction" of the bones forming a joint, that is, the pulling them apart, is manifestly desirable when the inflamed epiphyses are being crowded together either by jar or muscular pressure. Exaggerated pressure of two inflamed bony surfaces of a joint upon each other increases the danger of necrosis and the extent of the destructive osteitis, by diminishing from pressure the blood supply proper to the separation of the inflamed parts and the development of the formative or cicatricial osteitis, from which a cure is to be expected. In certain joints, as the elbow, sacro-iliac, symphysis pubis, distraction is impracticable, and in certain others, as the knee and shoulder, it is not difficult, and in the hip it is of great importance in cases of epiphyseal osteitis. In pure synovitis, where there is no danger of extension to the bone, there is little need of distraction. This, however, is a rare condition in the larger joints if extensively inflamed.

The operative procedures, aspiration, arthrectomy, and arthrotomy, will be considered severally under the headings of each joint where they are to be borne in mind as therapeutic methods.

The employment of these several methods varies not only in the different affections of the joints, but also in the different joints, certain methods being especially adapted to the anatomical conditions of certain joints; the subjects, therefore, will be separately considered under the heads of the various joints.

TREATMENT OF CHRONIC DISEASES OF THE HIP-JOINT.—*Chronic Epiphyseal Osteitis.*—Chronic epiphyseal osteitis (hip disease par excellence), the most formidable joint disease to be encountered, demands all of the surgical resources at command. The indications in treatment of hip disease are to furnish, severally, fixation, distraction (extension), protection for the benefit of the patient's general condition; to prevent and correct deformity; to allow locomotion as far as is compatible with the surgical indications; and to meet such complications as periarticular inflammation, abscess, and sequestra, as may arise.

Treatment, it is manifest, should be adapted so that it can be continued not only during the active and subacute stages of the disease, but also during the convalescent period, and until the affected joint is able to stand the jars incident to locomotion without fear of recurrence of the disease.

Fixation.—The means generally used for fixation are: 1. Plaster of Paris bandages, or leather and metal splints applied to the hip, pelvis, and thigh, for fixation. 2. The Thomas splint. 3. Gouttière de Bonnet, "wire cuirass," or some modification of it.

Plaster bandages. These furnish an imperfect form of fixation, as they do not firmly hold the trunk above the pelvis, and, owing to the possible motion of the lumbar spines, the pelvis is able to move within the bandage, thus allowing motion of the acetabulum and distortion of the limb. This is equally true of leather splints of this sort.

Thomas Splint. The Thomas hip-splint, introduced by Mr. Thomas, of Liverpool, is an appliance used in England, and has many points of usefulness. It does not, however, furnish complete fixation, nor does it prevent the occurrence of subluxation, or counteract the spasmodic muscular contraction of the muscles connecting the lower extremity with the pelvis—so important a feature in hip disease. The appliance, however, prevents motion of any noticeable amount, enables the patient to be lifted without jarring the hip, and prevents flexion of the thigh. In certain acute cases the pain may be increased by the Thomas splint, from the fact of the imperfect fixation furnished. The leg and thigh are firmly held by the appliance, *i.e.*, the flat rod, to which they are bandaged. This rod extends up the trunk, and cannot be so firmly fixed to the trunk but that some motion is possible at its upper end, as the patient turns in bed or moves. Motion of the upper end of the rod is, of course, communicated to the lower, and the joint may, in this way, be twisted and jarred by the long lever attached to the thigh.*

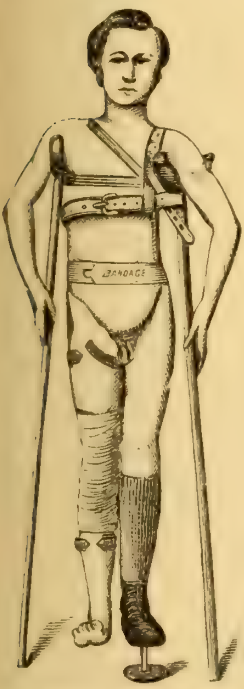

FIG. 4943.—The Thomas Splint Applied. Front view.

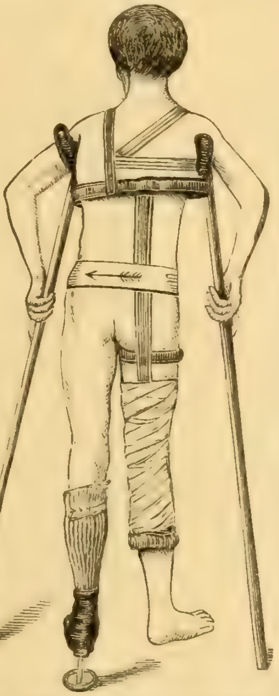

FIG. 4944.—The Thomas Splint Applied. Posterior view.

Wire Cuirass. The Gouttière de Bonnet, or wire cuirass, furnishes excellent fixation.† It is, however, cumbersome and expensive, and has the defect of not thoroughly giving the benefit which can be afforded by distraction, in relieving the increased intra-articular pressure.

Distraction.—All the above methods of attempted fixation overlook the injurious influence of muscular spasm of the muscles about the hip, in spasmodically jarring the hip-joint, and in exerting an undue pressure by crowding the inflamed epiphysis of the femur against the acetabulum. This reflex spasm of the muscles about a joint is constant in all inflamed joints surrounded by muscles. It is of special importance in hip disease, from the strength of the muscles about the joint. Such spasm prevents rest of the joint, increases the pressure on the inflamed bone, causes distortion of the limb, absorption of the head of the femur, enlargement of the acetabulum, and subsequent subluxation of the femur. The force of the pressure can be estimated if we consider the great strength of the muscles extending from the pelvis to the femur. A sudden spasmodic contraction of all these muscles drives the head of the femur against the acetabulum with the force of a sharp blow, and unless this is overcome, no attempt at securing rest of the joints is complete.

To counteract this injurious muscular force, a pull upon the femur away from the acetabulum is necessary. This is often instinctively attempted by patients, who press the foot of the well limb on the dorsum of the foot of the affected side, in the endeavor to force the limb away from the acetabulum.

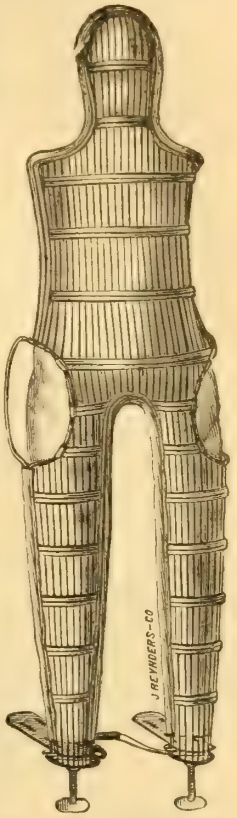

FIG. 4945.—The Wire Cuirass.

The influence of a distracting force has been denied by some writers, who claim that it is impossible to draw the femur away from the acetabulum. This is not only disproved by clinical experience, in the relief afforded by a distracting force properly applied, but the distracting effect of such force has been demonstrated by experiment.[56]

The head of the femur is held close to the acetabulum by the cartilaginous collar (cotyloid ligament), which is a prolongation of the acetabulum. In a healthy hip-joint, if all muscles are dissected away, it will be found difficult, if not impossible, to pull the femur from the acetabulum, if the pull is exerted in the line of the trunk; if, however, the limb is abducted, and a pull exerted in a direction not counter to the strength of the ligament, actual distraction takes place.

In a fœtus, or young child, distraction is easy from a downward pull in almost all directions, for the cotyloid ligament of a fœtus is not well developed. In hip disease the cartilage becomes softened and practically absorbed, and therefore cannot offer the resistance to distraction which is to be met in a healthy joint.

If a distracting force be applied with the limb strongly adducted, the head of the femur is brought against the rim of the acetabulum. This is not the case if the limb is slightly adducted, or if the acetabulum has not attained its normal adult development. But in well-marked hip disease in children, with softening of the cotyloid ligament and imperfectly developed acetabulum, distraction is as feasible as at the metacarpo-phalangeal articulation of the forefinger, where the bones of the joint can easily be separated by traction.

The effect of distraction can be readily estimated by any surgeon, if, in excision of the hip, before dislocating the head of the femur, the finger is placed on the head of the femur close to the rim of the acetabulum. If an assistant pulls upon the limb, the finger can be inserted between the head of the femur and the acetabulum. If the traction is discontinued, the pressure upon the finger will be found to be considerable. This pressure does not, of course, indicate the pressure due to muscular force, which is eliminated under an anæsthetic.

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* A substitute for the Thomas splint, made of stout iron wire, introduced by Dr. A. T. Cabot, of Boston, will be found of use in the case of smaller children, and is more readily fixed than the ordinary Thomas splint.

† For a modified and improved wire cuirass, see Nicaise, Revue de Chirurgie, 10 Janvier, 1888.

A distracting force can be applied therapeutically, by means either of the well-known weight and pulley method, or of distraction splints.

The former method of distraction or, as it is commonly termed, "extension," is frequently employed and is often of great assistance, but it is often inefficiently applied.

The following mistakes are not uncommon:

1. The use of a weight too small to counteract the muscular spasm at the hip.
2. The neglect of a counter-extending force, or the use of an imperfect one.
3. Imperfect hold upon the leg and thigh.
4. Improper fixation of the patient's trunk and limb, allowing motion so that the distraction will fall upon the knee and not upon the hip joint.
5. The use of the pulling force in such a direction that the force is not exerted in the line of deformity.

(a) The amount of weight to be used should vary according to the case; the patient's sensation may be trusted in a measure. In cases of severe spasm as much as twenty pounds will be found to be well borne; in light cases and in small children four or five pounds will be ordinarily sufficient.

(b) The readiest counter-extending force is the weight of the body employed by raising the foot of the bed five or six inches, and causing a tendency of the body to slide in a direction opposite to the extending force. A perineal strap attached to a weight and pulley pulled in an upward direction, may be used, but it is not as convenient and no more efficient than the weight of the body applied as mentioned.

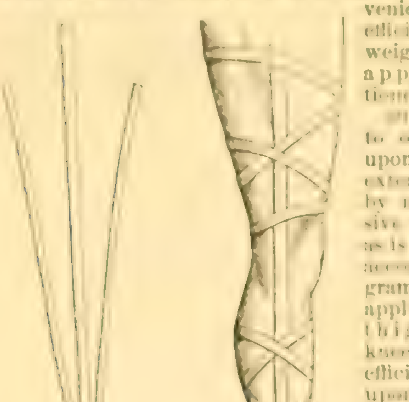

Fig. 4946.—Adhesive Plaster for Traction.

(c) The best way to obtain the hold upon the limb for an extending force, is by means of adhesive plaster applied as is indicated in the accompanying diagram. It should be applied firmly to the thigh above the knee, so as to secure efficient traction upon the condyles of the femur. If applied to the leg alone, distraction falls upon the knee and may cause relaxation of the knee joint. Efficient plaster should be used of a kind that will adhere readily without being heated. The prepared plasters furnished by Seabury & Johnson, and Grosvenor & Richards, answer the purpose best. The plasters should be changed every three or four weeks, or sooner if they cause irritation. They can readily be removed if the skin and plasters be thoroughly moistened with benzine. If any portion of the limb is chafed by the plaster, it may be protected by means of a cloth placed over the part, and the plaster is applied over the cloth and the whole limb; or if the chafing is extensive, the whole limb can be covered with vaseline and protected by a smooth bandage, and the plaster put on over the bandage to the limb. This will require frequent renewal, but will answer temporarily. It is usually the practice to apply a bandage over the plaster, but this impedes the circulation, and increases the danger of excoriation or chafing. If a bandage be applied, and worn for a few hours after the plaster is first put on, sufficient adhesion of the latter will be secured if proper plaster is used.

(d) If the patient be allowed to roll about in bed, or sit up, or to hold the limb flexed at the knee, it is useless that a proper distracting force is used. The patient, if restless, should be secured by the use of shoulder straps fastened to the bed, and by the use of sand-bags; or better still, he may be restrained by means of the bed frame to be described.

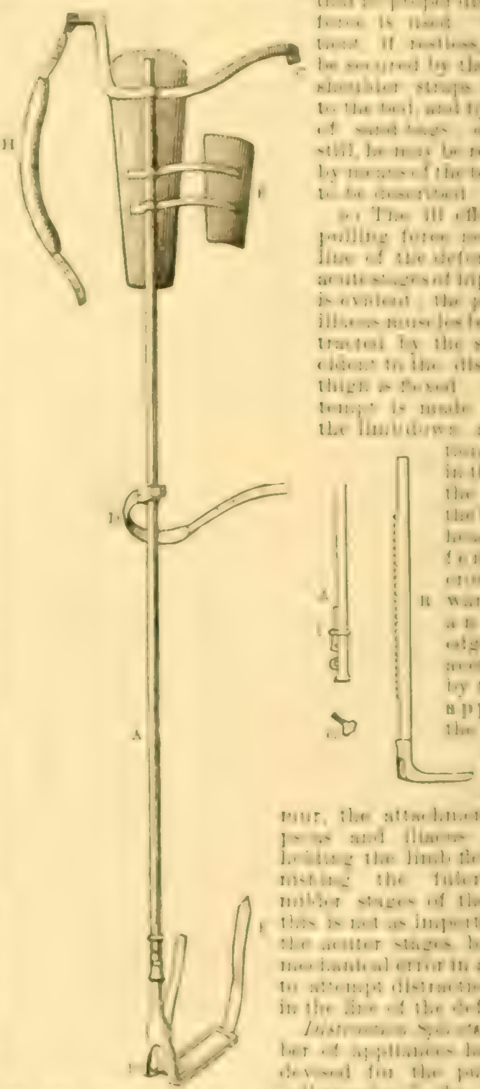

Fig. 4947.—Distraction Splint.

(e) The ill effect of a pulling force not in the line of the deformity, in acute stages of hip disease, is evident; the psoas and iliacus muscles being contracted by the spasm incident to the disease, the thigh is flexed. If an attempt is made to force the limb down, and traction be made in the line of the axis of the body, the head of the femur is crowded upward to the anterior edge of the acetabulum, by the force applied at the end of the lever, viz., the femur, the attachment of the psoas and iliacus muscles, holding the limb flexed, furnishing the fulcrum. In milder stages of the disease this is not as important as in the acuter stages, but it is a mechanical error in any stage to attempt distraction except in the line of the deformity.

Distraction Splints.—A number of appliances have been devised for the purpose of "distraction," the principle of which is practically the same, viz., perineal resistance with a pulling force exerted on the limb. As in most appliances, however, the details of the application of these principles are of so much importance that the efficacy of such treatment will depend on the details.

For efficient distraction by means of splints, it is important: (1) That it be possible to adjust the splint so that the amount of distracting force be regulated and properly applied. (2) That the perineal resistance be arranged so that great pain should not be caused in that way if efficient force is applied. (3) That a proper hold upon the limb be possible for some time. The latter has already been discussed in speaking of the weight and pulley method.

The perineal resistance should be so fixed that the perineal straps do not constrict the thigh. The straps should not be elastic and yielding, giving an uncertain resistance, and they should be made of proper material and padded, so that they do not wrinkle or cut at the edges. If the perineum be well anointed with vaseline, and the straps be properly made and padded, no serious trouble need be encountered.*

The first of the essentials above mentioned is easily accomplished, usually by means of a sliding rod moving within a tube, the amount of motion being controlled by means of a key (G) and ratchet (R), a spring securing the rod when in the proper position. This constitutes the well-known Davis Taylor extension splint, illustrated in Fig. 4947.

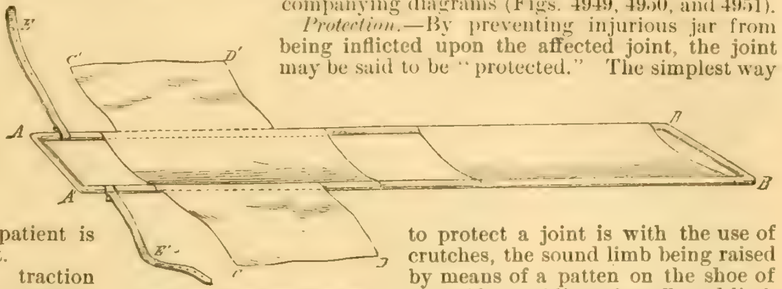

Fig. 4949.—Fixation Frame.

A traction splint manifestly furnishes certain advantages over the method of distraction by weight and pulley, in that distraction is possible while the patient is going about.

A short traction splint was at one time in use, but it cannot be relied on as efficient.

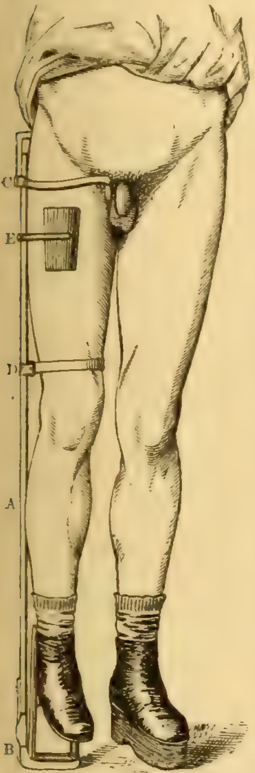

Fig. 4948.—Distraction Splint Applied.

The distraction splint consists of a rod, A, hollow at the lower part into which a rod, B, with teeth cut on the edge plays, by means of a key, G. The rod can be moved up and down, and it is caught and held in place by means of a spring, I, and sliding catch. The lower end of B is furnished with a broadened end, bent so as to pass under the foot, and through which a strap, F, can be slipped which is attached to buckles secured to the adhesive plaster on the patient's leg. To the upper end of A is secured an arm, C, which passes in front of the thigh, and to which a strap, H, passing under the perineum, can be buckled. A plate, E, in front of the thigh keeps the splint from slipping backward, and the arm D passes under the thigh and holds it firmly, and prevents the splint from slipping forward.

The arm C can be made longer, so as to pass around the waist, and hold a second perineum strap passing under the other buttock.

The splint is necessarily modified somewhat to fit different patients, but the above diagram illustrates the principle.

It has been claimed by some writers that if thorough distraction is employed, fixation beyond what is furnished by the distracting appliance is unnecessary.

Although this may be true theoretically, and practically many cases may be successfully treated without complete fixation, yet it cannot be assumed as a surgical aphorism that, where fixation is indicated, it can be furnished by a distracting force.

It is also true that thorough fixation of the hip is not possible without distraction. Efficient fixation can be furnished in the following way, illustrated by the accompanying diagrams (Figs. 4949, 4950, and 4951).

Protection.—By preventing injurious jar from being inflicted upon the affected joint, the joint may be said to be "protected." The simplest way to protect a joint is with the use of crutches, the sound limb being raised by means of a patten on the shoe of that side, enabling the affected limb to swing free of the floor. The weight of the limb exerts a certain amount of distracting force, and it was at first supposed that hip disease could be treated in this way alone.[122] Although this supposition has not been justified by facts, and it has been found that distortion of the limb and subluxation will not be prevented by this method, yet excellent protection can often be secured in this way.

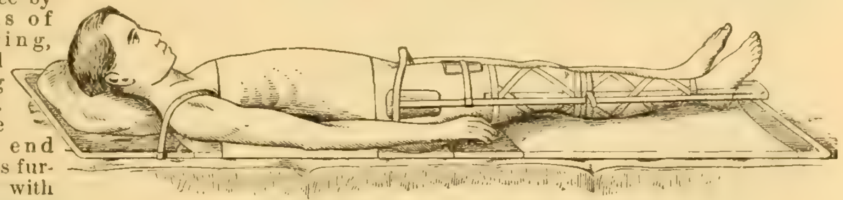

Fig. 4950.—Fixation Frame, with Patient in Position.

It will be found, however, that in many cases especially among children, it is difficult to prevent them from discarding crutches before it is safe to do so, or from kneeling upon the affected limb and in that way endangering the hip. Crutches also demand the use of the arms, and in adults the use of the arms for other purposes is desirable in the long period during which protection is needed. A protection splint is therefore of importance. The ordinary "extension" splint, as shown in Fig. 4947, is, in reality, a protecting as well as a distraction splint, as it is longer than the limb and passes under the foot, enabling the weight to be worn upon the splint instead of the patient's foot. Protection without distraction can be furnished by omitting the sliding rod, and continuing the upright rod below the foot, and expanding it at the bottom, as in the extension splint, or by inserting it into a socket in the boot. The rod should be long enough, and the boot so arranged that the patient's heel shall not touch the sole of the boot, though the ball of the foot may do so. The greatest jar in locomotion comes as the heel strikes the ground at the

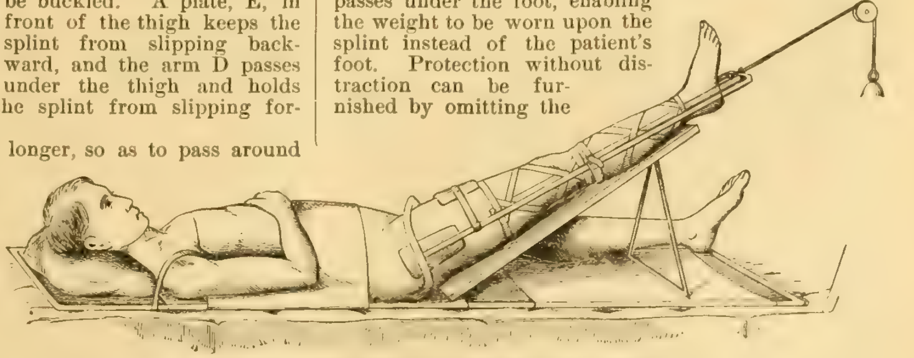

Fig. 4951.—Fixation Frame, with Inclined Plane Attached.

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* An excellent modification of the perineal strap to be used, devised by Dr. Brackett, will be found described in the Boston Medical and Surgical Journal, October 6, 1887.

commencement of the step. If this gait is broken by the splint, the remaining use of the hip in the step will be diminished at the ankle and knee, and the hip will be sufficiently protected, except during the acuter stages of the disease.

A protection splint can be made hinged at the knee, and if properly adjusted patients can walk about readily with but slight discomfort. In this way reliable protection is secured during the long period of convalescence necessary for the thorough ossification of the affected epiphyses.

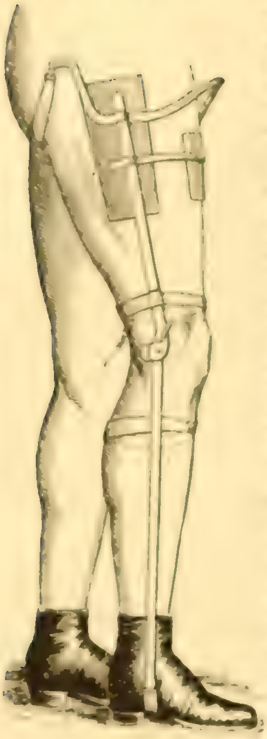

FIG. 1622.—Protection Splint Applied.

If proper protection is neglected and not continued for a sufficiently long time, the jar of locomotion, the whole weight being thrown upon the epiphysis previously carious, is sufficient to prolong the stage of irritability, to prevent complete cicatrization and ossification of the inflamed bone-tissue, to promote contraction of the limb and distortion, and in many instances to give rise to relapses.

An appliance which will not interfere with locomotion, which will readily allow walking and the free use of the **arms, which is not a great disfigurement, and can be** worn without discomfort for years if necessary, is of great use in the convalescent treatment of hip disease. It not only prevents relapse, but also prevents deformity. It is, of course, only indicated in the convalescent stage, and would be injurious in an acute stage.

Simple protection without distraction is not to be relied upon if muscular spasm is present; this point can be determined by palpation of the muscles of the hip. If muscular spasm is present, **protection and distraction should both be employed.**

Summary of Treatment.—The proper treatment of hip disease is not the exclusive use of any splint or method (i.e., of rest or extension), but the use of such means as may meet the indications that are present. During the acute stages the hip-joint should be fixed efficiently. This implies rest in bed, with fixation, and the use of efficient traction. Continued confinement to bed is not beneficial for the general condition of tuberculous patients except temporarily during the acute stage; and as soon as the acute symptoms have subsided the patient should be allowed to go about with the hip thoroughly protected against jar and spasm. This can be done by means of a distraction splint if efficiently applied.

At first, until patients become used to a splint (the **Davis-Taylor splint), crutches will be found an aid in** locomotion. If the acute symptoms return under this method, thorough fixation and rest in bed are again indicated. If the subacute symptoms diminish and there is less **muscular rigidity at the hip-joint, greater freedom** can be allowed, and eventually distraction discontinued, and the joint merely protected from jar. This should be continued as long as there is any danger of recurrence of active symptoms, or any tendency to contraction.

In brief, the hip should be fixed as long as it is sensitive, **should** be protected and distracted as long as there is muscular spasm, and protected as long as it is weak. The best results are attained only by great care for a year at least, and careful supervision and protection for two or three subsequent years. Distortions of the limb should always be prevented, and in many cases some motion can be saved at the hip-joint, if protection is not discontinued too soon.

Excision of the Joint.—In the severer cases of hip-joint disease, the question of excision demands consideration. The ultimate results after excision are not as satisfactory as at first supposed. The operation is in itself not a very dangerous one. If early excision is done, the percentage of recoveries is quite large, and excellent motion at the joint is often secured with the formation of a new joint (*Archiv f. Clin. Chir.*, Bd. xix., Heft 2, p. 409, and *Boston Medical and Surgical Journal*, April 23, 1885, p. 389). Yet the usefulness of the limb is claimed not to be as great as after the cure by conservative treatment. Holmes (*Medical Times and Gazette*, November 3, 1877) considers that the claim of the operation for adoption lies in its success in saving life where natural cure seems improbable. These cases are rare if care for years can be provided. Hüter (*Centralblatt f. Chirurgie*, No. 2, 1879) analyzed 288 cases of excision of the hip-joint; of these 134 died, 75 did not remain under observation; of the living, in only 61 were the ultimate results as to usefulness of the limb ascertained. Of these 41 were able to walk about without apparatus, 15 needed an apparatus, and 5 had no use of the limb.

A committee of the Clinical Society of London appointed to investigate the subject of the ultimate usefulness of the limb after hip-joint disease, reported the following result of their investigation of 320 cases. The percentage of mortality was forty, and of recovery forty-two. In fifteen per cent. death followed directly from the operation; in thirteen per cent., from phthisis; in six per cent., from albuminoid nephritis; in four per **cent.,** from other causes not connected with the hip affection. The treatment of those who recovered lasted one year and three-fourths; the duration of the affec**tion was three** years, and the average shortening of the limb was two and three-fourths inches. The indications for resection, as reported by the committee, were as follows: 1, Necrosis of the head of the femur and separa**tion into loose** sequestra; 2, firm sequestra of the head of the femur and the separation into loose sequestra; 3, **extensive caries of the femur or pelvis, with fistula**; 4, pelvic abscess with disease of the acetabulum; 5, chronic synovial suppuration, with disease of the cartilages of the acetabulum; 6, luxation of the femur on to the ilium, with chronic suppuration and fistula; a condition indicated by early suppuration and general symptoms.

Resection is also indicated in albuminoid degeneration, in cases with a great deal of suppuration and continued loss of strength in spite of care and rest, and also in pel**vic suppuration for the purpose of better** drainage.

Excision gives greater mobility than does conservative treatment, but the gait is much less certain and more limping.

Aseptic surgery has apparently reduced somewhat the mortality from excision at the hip-joint, but has not increased the usefulness of the limb after excision, nor in any way prevented a relapse.

The mortality also varies according to the stage at which the operation is done; during the first stage among children it is 0; in the second stage, 24.1 per cent.; and in the third, 67.5 (Grosch).

Yale's conclusions in regard to excision **of the hip-joint** represent well the present opinion of American surgeons. He says "that excision of the hip is indicated as a life-saving operation only," and that "as it has not been shown that it can save from any danger, except those consequent upon prolonged suppuration, it is, with rare exceptions, only indicated when the suppurative process has evidently reached a dangerous point and cannot be interrupted by any less serious operation."

For further details as to the procedure of excision, the reader is referred to the article on Resection.

As a substitute for excision, König, Volkmann, and **others** have advised, and successfully carried out in certain cases, a method of operative treatment by cutting down upon the bone and removing the diseased portion of the epiphysis by the chisel or curette, without sacrificing the joint. Such a method, however, is only possible in early cases, and in cases where the joint proper is as yet unaffected—cases with difficulty recognized.[129]

Amputation.—Of the still more radical method of amputation little need be said here (*v.* Amputation) except that, in cases of extreme hip disease, it is often to be regarded as a life-saving measure. The percentage of mortality of amputation for hip disease is not as great as that of amputation for injury or malignant disease.

Treatment of Complications.—Abscess. In certain cases of hip disease the epiphysitis is either so diffuse or so slight that the cicatricial process follows the inflammatory process of the bone without undue cell proliferation; but in others the tuberculous focus is neither encapsulated nor absorbed, but is sloughed out, and, causing an irritation, an abscess follows. This again may be absorbed or it may require treatment.

Simple cold abscesses secondary to hip disease can with safety be left to themselves, if not causing constitutional disturbance or increasing rapidly. It is desirable, however, that pus should be prevented from burrowing or extending in a great variety of directions. This can, in a measure, be done by bandaging the limb, and is done if an extension splint is worn efficiently; the pus being checked from extending along the sheath of the fasciæ by the resistance caused by the perineal strap and the pressure of the padded plates. If the abscess extends, it is well localized in a large majority of cases, and can extend only outwardly.

Aspiration is of assistance in many instances; in some, however, either the fluid contained in the abscess does not flow readily through the aspirating needle, or the latter is directly plugged by the caseous clots. In some instances abscesses have been entirely absorbed after one or two aspirations.

Injection of iodoform into an abscess cavity or hyperdistention by carbolic acid solution have been recommended. The latter involves the occasional risk of carbolic acid poisoning, which may be fatal.

Abscesses that are well localized, if allowed to open spontaneously, are often thoroughly evacuated, leaving a sinus which, discharging for some time, finally heals. Often, however, the abscess is not completely evacuated. Some residue remains, and, gravitating along the lines of fasciæ, gives rise to another abscess, and in this way several may be developed about the joint. It is better in such cases to open the original abscess freely, so that thorough drainage is furnished—large incisions being better than small. The pyogenic membrane should be dissected off or curetted. If that is done, with thorough asepsis, and proper dressings applied, it is not uncommon, when active disease of the bone has subsided, for such abscesses to heal up entirely by first intention, without recurrence or sinus. To gain such results two things are essential, viz., thorough drainage of the whole abscess and perfect asepsis. It is, of course, necessary that thorough treatment for the osteitis be not interrupted.

Nocturnal cries. A troublesome complication in the early stages of hip disease is often the nocturnal cry. This usually disappears after thorough fixation with distraction. In some instances, however, the cries persist for weeks or months. They are certain to disappear in the second stage of the affection; they can be checked by opiates, narcotics, chloral or chlorodyne, if not stopped by proper fixation. Stretching the sciatic, trephining the head of the femur, and direct incision of the joint have been advised and tried with success in aggravated cases of this sort.

Distortion. Distorted attitudes of the limb are incident to the clinical history of hip disease, and the correction and prevention of them form an essential part of treatment. In the earlier stages of the disease there is little difficulty in correcting the existing deformities due to abnormal muscular contractions or malpositions of the limb—the ordinary treatment of hip disease being sufficient to correct deformity. If distraction is applied in the line of the deformity, in the early stages of the disease, it will be found, in a few days, that the limb can be placed in a more nearly normal position until it eventually becomes straight.

The deformities occurring are flexion, abduction, and adduction. Flexion can be corrected by efficient traction in the line of the deformity, as already mentioned. It will be found that a traction splint is more efficient for this purpose than the simple weight and pulley; the patient should be fixed in bed, a traction splint applied, the flexed limb raised to the angle of deformity so that the back is flat, and, if necessary, the weight and pulley may be attached to the splint in order to give additional fixation to the limb. It will be found that each day the angle of deformity is less and the limb can be lowered. Flexion can also be corrected by means of the Thomas splint bent to fit the flexed limb and gradually straightened. In the severe cases rest in bed hastens the correction in this way.

Abduction usually corrects itself under the ordinary treatment for hip disease, or is changed to adduction in the natural course of the disease.

The same may be said of adduction, but this latter distortion is often more persistent. It can often be corrected by the ordinary weight and pulley method, with fixation in bed. The correction can be helped by counter-extension applied to the well limb, by means either of a perineal strap or of a weight and pulley arrangement attached to the sound limb, and pulling at the head of the bed in opposition to the force on the affected limb pulling at the foot of the bed. The result of the two forces is to correct the adduction. The most efficient appliance is one recommended by Dr. H. L. Taylor, of New York (Fig. 4953).[130]

In later stages of severer deformity forcible straightening under an anæsthetic, with or without division of the adductor tendons and the division of the fascia lata, or with division of all fasciæ by open incision, or osteoclasis, or osteotomy, has been advised,[131] and is of help.

Of all the operative procedures subtrochanteric osteotomy is the preferable one (see article in this HANDBOOK, Vol. V., p. 391) in bony anchylosis with deformity.

Osteoclasis has been used, but the fracture cannot be as precisely located as can be done in osteotomy, a procedure which has been so thoroughly simplified that it may be considered devoid of danger.

In cases of deformity with fibrous anchylosis, correction can be made by mechanical means, but in the severest cases much time and patience are required.

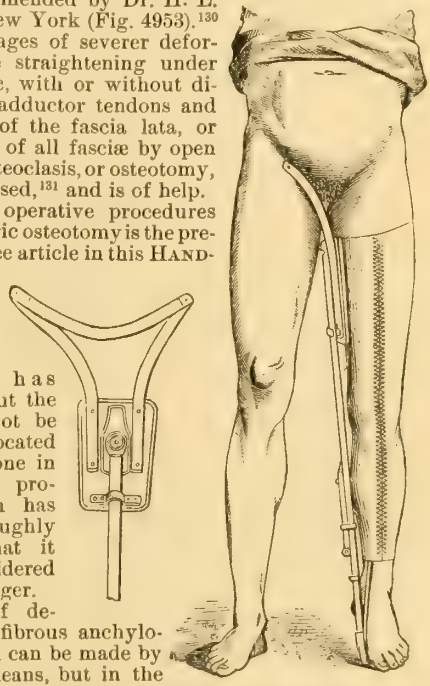

FIG. 4953.—Adduction Splint.

In cases with subluxation and absorption of the head of the femur and enlargement of the acetabulum the deformity entailed is necessarily permanent so far as the alteration of the bone is concerned, but the accompanying flexion and abduction can be corrected. Subluxation and the attendant distortion should not occur in the course of hip disease, as they are preventable, and their presence indicates a lack of thoroughness of treatment.

Shortening of the limb. Shortening of the limb after hip-joint disease and after excision occurs in a certain number of cases without satisfactory explanation; the shortening is not limited to the femur, but occurs also in the tibia and fibula and the foot.[132] Nothing can be done to prevent this arrest of growth. Prevention of the development of the disease and such use of the limb as is compatible with safety of the joint (inducing proper circulathat at the [illegible] may be regarded as the only means at our command.

Synovitis of the hip-joint.—Cases of chronic synovitis of the hip-joint are to be treated in the same way as cases of tubercular osteitis, if from the severity or duration it may be supposed that there is danger of extension of the disease to the cartilage and bone. The principles of treatment already enumerated—fixation, protection, and distraction—are to be considered in such cases. Cases of this sort do not require so long-continued treatment as those in which the epiphyses are attacked.

Chronic rheumatoid arthritis.—The treatment of chronic rheumatoid arthritis of the hip is the same as the treatment of chronic rheumatism in general. In the severer cases protection in the form of crutches, cane, or appliances will be sometimes needed. In the severest cases the deformities may need to be corrected by mechanical means, as in the earlier stages of hip disease. Massage, douches, hot and cold applications, and electricity alleviate the symptoms.

Functional affections of the hip.—Neuromimesis of the hip (hysterical affection of the hip, neuralgia of the hip) is not to be regarded or treated as a local affection. As a rule, it may be stated that the less local treatment given the better the result will be. For the mental management of the case it is sometimes necessary to assume the existence of irritation at the hip, but the treatment should be directed toward an improvement of the nervous system—either absolute rest, with general massage and forced feeding, or the reverse, viz., of diversion, with mental rest but physical and muscular exercise.

In some instances of hysterical contraction at the hip-joint an appliance is needed to correct deformity, but unless this is accompanied by management of the general condition such treatment will not be permanently beneficial. If thorough management is possible local treatment even in such cases is often unnecessary.

In cases of hysterical hypersensitiveness at the hip-joint crutches may be temporarily needed to enable the patient to go about. They should not, however, be used except as a means to give the patient confidence in locomotion in the early stages of treatment, and should not be used for a length of time.

PROGNOSIS OF HIP DISEASE.—Judging from the limited statistics at our disposal, the prognosis of hip disease in regard to life and to recovery of a useful limb is encouraging, but a long time is required in all cases. In 80 cases collected by Gibney,[133] where no particular treatment was adopted except constitutional measures, the results were as follows: In 33 the disease lasted three years; in 28 from three to six years; in 1 case fifteen years. In 48 of the cases abscesses had existed. Out of the 80 cases motion was reestablished in 12, in arcs of from fifteen to ninety degrees. In 71 cases the cure was accomplished before the fifteenth year. In only 8 of these was there such deformity as would interfere with walking. In a large majority of these cases there was only two inches of shortening; the amount of shortening varied between 1 and 3 inches.

Cazin reports that in 80 cases of suppurative hip disease treated at the hospital at Berck, in the course of five years, fifty-five per cent. were cured, twelve and one-half per cent. died, twenty-five per cent. were not cured, seven and one-half per cent. were improved when removed. Cazin has seen recovery in desperate cases. In 15 cases of suppurative coxitis with albuminuria, 5 died under conservative treatment, 2 were discharged improved, 6 not improved, and 2 cured.[134]

These cases of Cazin were all but 10 severe cases, sent from the Paris hospitals after they had ceased to improve there.

Of 288 cases collected by Gibney there was a mortality of twelve and one-half per cent. from exhaustion, meningitis, and amyloid degeneration.

In the Alexandra Hospital, London, there were 100 deaths out of 384, a mortality of twenty-six per cent.; of these, 260 were suppurating cases, and the death-rate of these was 33.5 per cent. Forty-two per cent. were reported cured.

C. F. Taylor, of New York, has reported 94 cases with only 3 deaths (1 by accident), and with recoveries in the remainder; of these 94, 24 were suppurating, and of these, 17 fully recovered.

Dhourdin reports fifty-three per cent. of recoveries in 257 cases of acetabular hip disease.

Hueter reports the mortality of hospital cases at twenty-seven per cent., and Billroth at thirty-one per cent.

Judson, of New York, in describing the treatment of 3 cases of hip disease of the third stage, has shown what can be done by careful treatment of these cases.

Shaffer and Lovett investigated 51 cases of cured hip disease which had been discharged from the New York Orthopædic Dispensary at least four years previously, and found that 41 had remained cured, some of the cases extending over ten years, and were all able to do a full day's work (although sometimes limping badly, only 1 used a cane). Of the remaining 10, 4 had died and 6 had relapsed, although 3 of the latter had been apparently cured a second time.[135]

In estimating the chances of an individual case, not only the severity of the disease has to be considered and the amount of resistance or recuperative power on the part of the patient, but also the amount of intelligent and skilled care possible in the case for a long time.

In few diseases is the benefit of thorough and long-continued treatment more clear, and in few surgical affections can the surgeon attempt to check the progress of disease and influence recovery with greater probability of success than in hip disease; but the surgical care and supervision should not be limited to the acute stages of the affection, but should be continued during the convalescent stage if the best results are desired.

KNEE-JOINT.—In considering diseases of the knee-joint, the varieties synovitis, osteitis, etc., have to be much more sharply borne in mind than is true of other joints, as these different diseases are clinically more easily distinguished and more common, and the differences more important. The methods of treatment common to all joints—viz., fixation, distraction, protection—are especially needed in affections of the knee. Fixation can be carried out in the knee-joint with much thoroughness. Effective fixation can be accomplished by means of stiff splints, by stiff bandages, plaster, silicate, starch, etc.

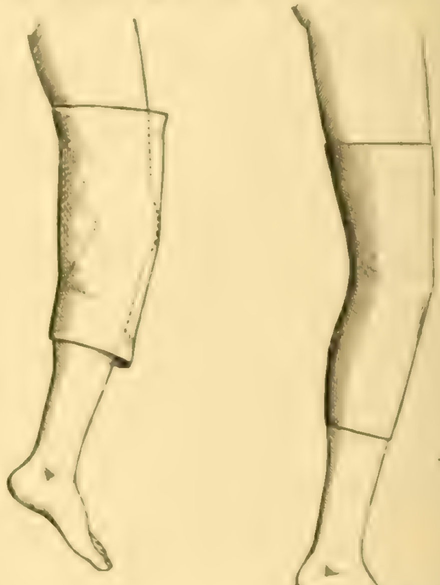

FIG. [illegible].—Incipient and Partial Flexion of the Knee.

The splint should be as long as possible in order to overcome the lever action of the segments of the limb above and below the joint. An additional reason for making the appliance of sufficient length is found in the fact that the thigh is well covered by soft tissues (Fig. 4954), and a certain amount of motion is possible owing to the yielding of the soft parts.

Distraction of the knee-joint is practicable in a relaxed condition of the ligaments and capsule. In a healthy knee-joint it is impossible to separate the tibia from the fibula owing to the strength of the lateral and crucial ligaments.

Counteraction of the reflex muscular spasm, so important in disease of the hip-joint, is needed in the knee chiefly to overcome the tension of the ham-string muscles, which tend to cause a subluxation of the tibia.

When there is a diseased condition of the epiphysis, and as long as that condition remains, the joint is incapable of bearing pressure or weight, and needs protection. Protection from jar is compatible with locomotion by means of crutches, or of an appliance longer than the limb, with arrangement for perineal support.

Compression is most readily applied to a knee-joint by means of a thin rubber bandage—Martin's bandage—wound about the limb; bandages of elastic cloth can also be used, but are not as efficient. Dried and compressed sponges, bandaged firmly about the limb, will expand when wet, and in this way compress the tissues of the joint effectively; or the knee may be thickly covered with sheet wadding and binders' board made pliable by immersion in hot water, and the whole bandaged firmly.

Innunction of fats, of oleates, and of medicaments, painting with iodine, etc., are remedies frequently used, but their value is questionable. The same may be said of cauterization.

Synovitis.—In chronic synovitis without effusion thorough fixation is needed in the early or acuter stages, with or without compression. The application of cold by ice-bags, evaporating lotions, cold douches, or the cold coil will often be a help, and in some instances hot cloths or poultices relieve pain. Counter-irritation, by means of tincture of iodine or blisters, and cauterization, are of doubtful value, except as expectants.*

In chronic synovitis with serous effusion the treatment is primarily to cause the absorption of the fluid by means of compression and fixation. Besides this, distraction and protection—one or both—are needed if there is danger of extension of the disease to the bone or cartilage, and fixation if there is any activity of disease; the choice of massage, of passive motion in later stages, or of fixation, is a question of judgment in each individual case, it being borne in mind that motion is a normal function of a joint, and that massage may be supposed, by temporarily improving the local circulation, to promote the absorption of synovial œdema or its results, and, on the other hand, that anything which increases the inflammation in a joint, like ill-judged motion, is an injury.

When the inflammatory stage is passed and there is no further danger of extension of the disease to the bones or cartilage, massage, as well as passive exercises, may be allowed. Twists and sudden jars are to be avoided, and protection (crutches or splints) is advisable in the stage of convalescence if the attack has been at all a severe or protracted one.

In synovitis with purulent effusion the joint should be thoroughly drained by incision and washed out. If the effusion is but slightly purulent, aspiration and thorough washing out will suffice. If, however, the pus is thick, or caseous clots are present, the joint should be freely opened by straight lateral incisions and well washed out with an aseptic fluid. The observance of strict aseptic precautions is of course necessary.

Hydrops Articuli.—In hydrops articuli (water on the knee) the treatment is such as would promote absorption or removal of the fluid. Besides friction and compression, which are often sufficient, aspiration is of great service. The procedure may be considered as free from danger. The best method of applying is as follows: after thoroughly cleansing the skin, the knee is bandaged with a rubber bandage to exert slight pressure, leaving a small portion uncovered for the insertion of the aspirating needle. This is best done at a little distance from the side of the patella. The size of the needle should depend upon the character of the fluid; if thorough asepsis is carried out a needle of large size or a trocar is free from danger. After the joint has been aspirated, the wound should be covered with a piece of aseptic gauze or cotton and a rubber bandage applied over the knee. If the fluid is again effused, the joint can again be aspirated.

When reproduction of fluid takes place, injection of iodine, as in the treatment of hydrocele, has been recommended and used, but sometimes the results have been disastrous. The injection of carbolic-acid solutions, or of corrosive sublimate solutions, is apparently efficacious, as well as thorough irrigation of the joint already mentioned.

Epiphyseal Osteitis.—In epiphyseal osteitis the treatment requires the greatest care to preserve the function of the joint as far as is possible, to arrest the progress of the disease, and to prevent and correct deformities. Fixation is demanded in the acute stages and should be thorough; in the subacute stages some motion is at times allowable, and in the stage of convalescence as much motion as is possible without direct jar to the joint should be allowed. Protection is demanded in all stages of the disease, and distraction in the acute and subacute stages. Aspiration of the joint, incision, injection into the joint, counter-irritation, may be all indicated, and in the severe cases excision or arthrotomy.

What was said in regard to the treatment of hip disease may be repeated in speaking of epiphysitis of the knee-joint. The treatment should be thorough, persistent, and should meet the indications. Fixation and protection are the most important indications in diseases of the knee, distraction being less so. The employment of protection should be continued until it is certain that the epiphysis is normal, a matter of judgment in every case. Protection should be discontinued gradually and tentatively; if discontinued too soon, recurrence will take place, or the deformity at the limb will increase. Fixation should be used so long as there is any activity of the inflammation; this is indicated by pain, muscular spasm, or tenderness. Efficient fixation of the knee does not require confinement to bed.

Protection can be furnished by means of crutches, raising the sound limb by a thick sole, and allowing the affected limb to swing clear of the ground. Better protection is furnished by means of a splint (with perineal support) longer than the limb and passing under the foot so as to

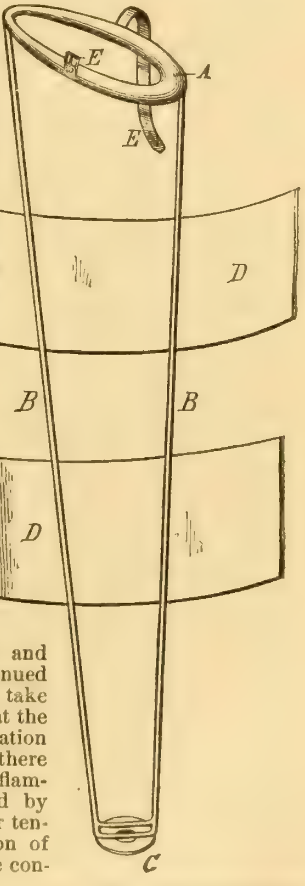

FIG. 4955.—Protective Splint for Knee and Ankle.

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* For the treatment of acute synovitis the reader is referred to the article Synovitis.

take the part of locomotion. The best of these splints is one similar to that already described as a protective splint in hip disease (Fig. 2962). It can be readily set at the angle of flexion of the knee and straightened as the limb straightens, and distraction can be added to the splint if necessary.

A simpler appliance is the Thomas knee splint, which consists of a padded iron ring fitted so as to surround the thigh at the perineum, and fastened to two rods, one on each side of the limb, longer than the limb and secured at the bottom to a metal plate below the foot (Fig. 2971).*

In cases of extreme disease of the knee-joint amputation of the thigh is necessary as a life-saving measure. In less severe cases the limb may be saved by excision (for the details of this procedure the reader is referred to the article on Resection). As for the indications determining a choice between excision and amputation, it can be said that where the patient's reparative power is slight an amputation is to be preferred. The question is largely one of individual judgment.

One danger from excision in children is that of arrest of the growth of the limb from removal of the epiphyses. For this reason *arthrectomy*† has been advised in children as a substitute for excision. The joint is opened as in cases of excision and the whole synovial membrane as far as it is tuberculous should be dissected out. If carious spots are found in the bone these foci should be removed by the curette or chisel. If the whole epiphysis is diseased excision is of course unavoidable, but in many cases this is unnecessary. Schede, Volkmann, and others have reported excellent recovery with complete healing without suppuration in a few cases of this sort, and similar success has followed the procedure in two cases in the practice of the writer. Strictest asepsis is essential, as well as a thorough removal of all tuberculous tissue in the affected part, necessitating sometimes complete dissection and removal of all of the synovial membrane, as well as careful curetting of the bone. The patella should be removed or left according to its condition. Either two straight incisions, one median incision, or a cross incision may be used. The patella may be divided and subsequently wired, or the ligamentum patellæ cut across. All tubercular tissue should be removed by the chisel, curette, or scissors.

Müller has collected reports of 22 operations: 1 died of chloroform-poisoning, 1 died of iodoform-poisoning, 2 died of general tuberculosis from eight to eleven months after the operation on the knee, which had been successful, 15 healed by first intention without a fistula in from three to ten weeks, and in the others a small fistula remained after the first operation, and a subsequent curetting was necessary before recovery took place. No deformity followed the operation in 6; the knee remained stiff in all but 2, in which there was a certain amount of motion possible.[10]

Statistics in regard to the ultimate results of treatment of disease of the knee are unfortunately of little value as a guide in the consideration of proper treatment of disease of the knee-joint; it may be said that aseptic surgery has materially improved the chances of recovery after excision, and that conservative treatment in children gives most excellent results in cases which can be watched and treated for a long time. The following figures are given by Wilkens of cases treated in the course of seven years at the Göttingen Clinic (see *Deutsche Zeitschr. f. Chir.*, 1885, Bd. 21, Heft 5):—

The treatment was fixation by plaster-of-Paris bandage preceded by extension, and with or without incision of abscesses, curetting, etc., or by resection, partial or complete, or amputation. Of the cases not operated upon, in three years fourteen per cent. recovered, fifteen per cent. died, sixty-six per cent. were still under treatment. In four years twenty-six per cent. had recovered, seventeen per cent. had died, fifty-seven per cent. were uncured. At the end of five years, including all cases operated on or not, twenty-nine per cent. remained uncured, eleven per cent. had been amputated (with a mortality of sixty per cent.), thirty-seven per cent. had been resected (with a mortality of fifty-one per cent.), and thirteen per cent. were well without operation.

It should be borne in mind that these figures represent hospital cases, presumably cases treated under more or less unfavorable circumstances.

Periarticular abscesses are to be treated in the same way as cold abscesses are treated in connection with other joints.

The results of conservative treatment of the tuberculous knee-joint may be excellent, but in severe cases a long time is necessary. In adults the prognosis of the conservative treatment of severe cases is much less satisfactory. The reverse may be said of excision.

Prevention and Correction of Deformity.—The deformity most frequently accompanying chronic epiphyseal osteitis is flexion; this can, in the early stages of the disease, be easily corrected by manual straightening under an anæsthetic, by a pulling force with a weight and pulley, by a distraction splint, by bandages and a fixation splint, or by repeatedly applied plaster bandages. If the deformity, flexion, remains uncorrected for some time in severe ostitis of the knee-joint a subluxation of the tibia backward takes place, due to the contraction of the hamstring muscles. If an attempt be made to straighten the limb the head of the tibia is held in its subluxated position by the contracted hamstrings and the posterior capsular ligaments, and if the leg is brought into the direction of the thigh the head of the tibia will be found behind its normal position and an ugly deformity will have resulted. This can only be prevented by a forward force exerted on the head of the tibia, pushing it around the end of the femur as the limb is straightened. Various appliances have been used for this purpose, and by the use of long-continued and persistent effort correction can be effected by proper splints.

In angular ankylosis at the knee resection for correction of the deformity is not without danger. Pénières collected 77 cases with a mortality of eight per cent. This was, however, before the days of aseptic surgery, for the same writer collects 36 operations and no death where aseptic precautions were used.[11] For the correction of deformity which has persisted for some time, forcible straightening under an anæsthetic is often necessary, or, in cases of bony ankylosis, osteotomy or excision (see Osteotomy, Resection). In fibrous ankylosis the readiest way to correct is first to forcibly flex (in order to break up adhesions without increased danger of rupture of the artery) and then extend, dividing the hamstring tendons if need be beforehand. Mechanical appliances are often recommended for the purpose of straightening, but are unnecessary if the following procedure be carried out in difficult cases. The patient is placed upon the floor on his back, and the surgeon stands over him, holding the knee with both hands, the fingers being placed under the popliteal space. The patient's ankle is grasped between the surgeon's knees. The whole weight of the surgeon's trunk can then be thrown upon the end of the lever furnished by the leg, the hands of the surgeon pulling upon the popliteal space furnishing the resistance. After the limb is forcibly flexed and the adhesions broken, it can be straightened if the patient is turned upon the face, a downward force being applied to the heel and resistance being furnished by a cushion placed under the patient's knee. Where subluxation is present it must be corrected, and this can be done by means of an appliance which will, however, be needed only in extreme cases.

After correcting the deformity the limb should be well surrounded with soft cotton and a stiff bandage applied, the limb being held straight until the plaster has become hard. The procedure is sometimes followed by pain, and opiates are necessary for a few days. In the lighter cases no such force is required, but the limb can, under an anæsthetic, be brought into position by manual manipulation.

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* In the figure of the protective splint (Fig. 2962) [illegible]

† The term "arthrectomy" has been applied to this procedure by some writers.

The dangers incurred by this procedure are not as great as would be supposed. Such a violent procedure should not be undertaken if there is inflammation present at the joint, but in the early acute stages little force is required to straighten the limb. The danger of rupture of the artery can be avoided by care. Separation of the epiphysis of the femur may take place, but is cured by the fixation requisite to treatment, and should not occur if the force is carefully applied. Fracture of the femur and tibia can be avoided by care.

The treatment of *chronic rheumatoid arthritis of the knee* is the same as that of the same disease elsewhere, as may also be said of syphilis and gout. In some cases of chronic rheumatoid arthritis protection is sometimes of use, distraction is not necessary, and fixation should be applied only temporarily. Massage, hot applications, and electricity may be of benefit.

Disease of Cartilage.—Three cases have been reported of circumscribed fungous disease of the internal meniscus. In one of these ignipuncture, and in two removing the granulations by scraping, resulted in recovery. Extirpation of the affected meniscus was followed by a cure with active motion of the joint. In another case the external semilunar cartilage was removed on account of chronic inflammation and a relaxed condition which interfered with locomotion. The operation resulted in healing by first intention.[138]

Loose Cartilage.—There are two methods for removal of loose cartilage at the knee: 1, The open incision, introduced by A. Paré, discarded by later surgeons, including B. Bell, who preferred amputation of the thigh, and revived again since the introduction of aseptic surgery; 2, the subcutaneous extraction, which is done as follows: the foreign body is pushed into the external upper cul-de-sac and held by the finger of an assistant under the triceps tendon, and by help of another kept from slipping up. An incision is then made with a tenotome in the subcutaneous tissue, directly under the synovial cavity, and in the synovial wall, directly under the foreign body, which is forced out into the cellular tissue: two weeks later the loose cartilage is removed by direct incision. The difficulties of the second step, namely, removal of the cartilage from the cellular tissue, are great, and several modern surgeons prefer the direct incision on account of the technical difficulty of the indirect method (*Revue de Chirurgie*, 1881, No. 1).

In removal of a loose cartilage by direct incision, an incision is made at the side of the patella, where the loose body is to be felt; the strictest asepticism is to be observed.

Displacement of the semilunar cartilage (internal derangement of the knee-joint) is the result of a sprain, and the symptoms and treatment are those of sprain at the knee with synovitis.

In the severest cases an anæsthetic is necessary in order to restore the cartilage to place, but after the cartilage is replaced by manipulating the joint immediately after the accident, the knee is to be flexed to its fullest extent, the tibia pulled upon as if to draw it away from the femur, and rotated; the limb is then suddenly straightened, the operator pressing upon the displaced cartilage at the same time. The cartilage sometimes returns to its place with a snapping sensation, but often without the patient's consciousness. Frequently the patient learns, by a sudden twist of the limb, to replace the cartilage himself. In some of the severest cases it has been necessary to remove the cartilage by direct incision.

Howard Marsh has used with benefit a steel clamp as a means of prevention of the slipping of the cartilage, when there is a tendency to recurrence. The clamp consists of two lateral pieces of thin steel, well padded and fitted to each side of the patella, connected by a spring passing behind the knee.[11]

Slipping of the Patella.—Occasionally, owing to an injury to the lateral fasciæ, or to a loss of tension of the quadriceps extensor muscle, the patella slips to the side, interfering with locomotion, and causing discomfort. Electricity applied to the muscle, with the idea of strengthening it, will sometimes be of assistance. The patella can be kept in place by a stout piece of leather moulded to, and covering, the knee, but with an opening into which the patella fits; this leather cap is then strapped behind the knee and held firmly in place.

ANKLE-JOINT.—In the treatment of the most formidable affection of the ankle-joint, viz., tibio-tarsal osteitis, protection from jar is especially indicated—as will be readily seen, if it be borne in mind that in locomotion the whole weight of the body is borne at each step upon the comparatively small surface of the articulating portion of the astragalus. Fixation of the ankle in a stiff bandage and allowing the patient to walk upon the limb, is a manifest error, occasionally made possible through confusion of a simple synovitis, which, at certain stages, needs fixation, with osteitis, which should be protected from jar at all stages. Protection can be furnished either by means of crutches, or, more thoroughly, by means of protective splints with perineal supports. Protective splints, described for the knee-joint, are needed in osteitis of the ankle.

Fixation is of advantage in the acuter stages of the affection, and is readily furnished by means of stiff bandages.

If abscesses form, they should be incised.

In cases of caries of the ankle, with extensive disease of bone, the decision to persevere in conservative treatment, or to resort to operative interference, is one which is based largely upon the patient's age, and the circumstances of attendant care.

In children, the results of conservative treatment are satisfactory. Satterthwaite reports 14 cures with useful limbs in 16 cases; the time of treatment being on the average two and one-half years; 2 of the 16 patients died (New York *Medical Record*, August 21, 1880).

In adults, however, the treatment is much less satisfactory in advanced cases of caries. Excision or amputation is not infrequently demanded in the worst cases.

Operative interference consists of curetting the sinuses or the removal of the diseased tarsal bones. It will be found that the latter procedure gives much the more satisfactory results where the osteitis has become so extensive as to have occasional sinuses; if it has involved a greater part of the astragalus, if the curette is unreliable as a means of removing all the disease.

Chronic synovitis of the ankle-joint is chiefly the result of sprains, and the treatment should be the same as that commonly used in the sprains of the ankle, viz., fixation, compression, massage, passive motion, occasionally protection; and the period of time required for the employment of these several methods varies according to the severity of the attack and the condition of the patient.

Fixation is readily furnished by the stiff bandages—silicate of potash or plaster of Paris—and compression by a rubber bandage. Care should be taken that the pressure comes upon the proper part of the ankle, and not upon the most prominent part, viz., the malleoli. The parts requiring pressure are the depressions in front and behind the malleoli, and these should be filled with pads of cotton, so that the pressure of the bandage should fall upon the capsule of the joint, and not chiefly on the malleoli; if there is much swelling at the ankle, this precaution is not necessary; but as the swelling subsides the malleoli become more prominent, and would bear the chief pressure of the constricting bandage.

Pure tuberculous synovitis not affecting the bones, an affection rarely encountered, should be treated with a view of preventing an extension of the disease to the bones—*i.e.*, in the same way as osteitis would be treated.

In severe chronic synovitis of the ankle-joint the indications are for rest, fixation, and, if swelling be present, compression. In cases where there is danger of extension of the disease to the astragalus or tibia, protection is advisable.

In the lighter cases of synovitis of the ankle-joint, or after the inflammatory stage has passed, the need of perfect fixation is not present, and massage, with protected or graduated motion, will be found of great benefit.

METATARSO-PHALANGEAL DISEASE.—In chronic affections of the joints of the anterior part of the foot and of the toes it is often desirable to allow locomotion without jar at the joint and to avoid the inconvenience of crutches or of appliances.

The shoe devised by Mr. Thomas, of Liverpool, seen in the accompanying diagram, will answer the indications of protection and fixation, at the same time allowing locomotion.

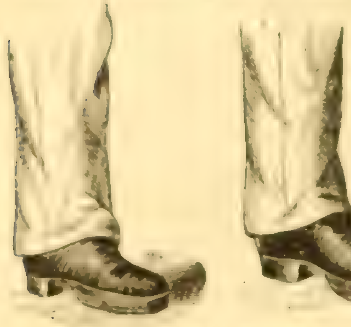

FIG. [illegible].—Shoe for Metatarsal Disease.

The shoe worn by the Chinese, with a thick stiff sole, cut away at a slant at the toes, answers the same purpose.

It is important, as a preventive measure, that shoes which are too short or which crowd the toes should be avoided; the foot should also be prevented from slipping forward, crowding the toes against the front of the shoe. This can be done by properly lacing the shoe against the instep and ankle, and furnishing a shoe of sufficient length.

SHOULDER-JOINT.—*Chronic Synovitis.*—In synovitis of the shoulder-joint with any active inflammation the indication is simply for rest and fixation. These are readily secured by means of a sling, and a bandage securing the arm to the side. Compression will be needed if there is swelling and effusion, and this is effected by surrounding the joint with cotton, and covering the whole by a felt or hard rubber shoulder-cap, which is firmly bandaged to the arm or shoulder.

Fixation should not be continued longer than there is subacute inflammation, and can be gradually discontinued; the bandage which holds the arm to the side being first discarded, and then, later on, the sling.

The question of the use of forcible passive motion in the convalescent stage is a vexed one. Where the adhesions are chiefly periarticular, or confined to portions of the joints, and are firm, forcible motion under an anæsthetic will be necessary, but in the majority of slight cases gradual passive exercises will suffice.

If the fixation is due to muscular spasm chiefly, forcible passive motion will be of no use, as the spasm reflex to the inflammation at the joint will reappear after the anæsthetic as long as the disease of the joint remains.

Local applications are to be used at the shoulder-joint for the same reasons and indications as at other joints.

Osteitis.—In tubercular osteitis at the shoulder-joints, the indications for treatment are practically the same as those present in chronic synovitis.

Distraction is not indicated in disease of the shoulder, as, owing to the laxity of the joint, the weight of the dependent arm, if kept at rest, is sufficient to separate the humerus from the opposing bone surface of the scapular articulation.

Abscesses are to be treated in the usual way.

In the severest cases excision of the shoulder is indicated, and excellent results are attained.

ACROMIO-CLAVICULAR AND STERNO-CLAVICULAR ARTICULATIONS.—Fixation and expectancy are all that can be done for these joints. Fixation can readily be secured by retaining the arm, as in disease of the shoulder-joint.

ELBOW-JOINT.—Synovitis of the elbow-joint recovers usually under fixation, which is readily obtained by fixation splints, internal angular splints, external angular splints, or a lateral splint to which the arm is strapped or bandaged. These splints can be made of thick pasteboard, reinforced with iron or wire (telegraph wire) or wood, and should be fitted to the arm bent to a right angle. Compression can be effected by surrounding the joint with cotton and bandaging it with an elastic rubber bandage. In time fixation by splints can be discontinued, and the support of a sling alone be relied on, with passive exercises and massage.

In cases of osteitis the treatment is the same, except that a much greater length of time is required, and abscesses requiring to be incised may supervene.

In the severest cases excision offers the readiest chance of cure.

WRIST.—The treatment of disease of the wrist-joint is to be conducted on the same principles as that of the other joints, and consists chiefly of fixation, by means of palmar splints, and compression. It may be mentioned, in regard to tubercular osteitis of the wrist, that excision, till recently rejected as an unjustifiable procedure, is of more usefulness than has hitherto been supposed. It is, of course, only indicated in the severest cases. Excellent results have been obtained by this procedure, chiefly in adolescents and young adults.

OTHER JOINTS.—Diseases of the sacro-iliac articulation, and of the temporo-maxillary articulation, have been already treated elsewhere in this work. (See under Sacro-iliac Disease and Jaws.) The treatment of the remaining joints requires no especial mention.

The writers are indebted to Drs. H. L. Burrell, H. W. Cushing, and E. G. Brackett for their assistance in the preparation of this article.

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LARYNX, NEUROSES OF THE.—Strictly speaking, neuroses of the larynx are disorders or diseases of some portion of the nerve-structures supplying the larynx, or presiding over its functional integrity; but practically, all disturbances in laryngeal functions normally performed under neural influences are to be included in the term. There are various disorders of the muscular, vascular, and glandular structures of the larynx which produce objective and subjective results so similar to those of true neuroses that their differentiation is difficult and sometimes impracticable. Hence the most instructive method of studying laryngeal neuroses will be to include all impairments of function, whether neuropathic in origin or not.

The neuroses of the larynx, like disturbances of the nervous system in general, comprise disorders of nutrition—trophoneuroses; of sensibility—æsthesioneuroses; and of motility—kinesioneuroses; all presumptively attributable to cerebral, cerebro-spinal, and neural lesions, or to molecular disturbances, whether perceptible evidences of alterations of structure in cerebro-spinal or nerve-tracts be manifested or not. Neuroses that are so manifested are recognized as organic neuroses. Such as are not so manifested are termed functional neuroses, although the inference remains that some undeterminable change of tissue or of tissue relation must have taken place. It is sometimes impossible to determine whether organic neuroses originate in the cerebral, spinal, or peripheric portions of the nervous system.

TROPHONEUROSES: NEUROSES OF NUTRITION.—Disease being due to disturbance between equilibrium of nutrition and work, excess of nutrition and of work produce permanent hypertrophy; excess of nutrition alone produces hypertrophy with subsequent degeneration; lack of nutrition produces degeneration and atrophy; and excess of work and lack of nutrition produce atrophy. In studying these nutritive changes the condition of the trophic centres and of their lines of distribution is a matter of great importance.

Hypertrophy.—Hypertrophy of laryngeal tissues occurs most frequently in connection with an inflammatory disease. It has occasionally been noted without assignable cause, and may be attributed, at times, to increased functional activity of trophic supply. I am unable to refer to any recorded instances of hypertrophy as of presumptively purely neural origin.

Atrophy.—Atrophy of the laryngeal tissues is frequently observed in connection with chronic diseases of inflammatory origin, with anchyloses of the crico-arytenoid articulation, complete or incomplete, and with both spasmodic and paralytic disorders of the laryngeal muscles. In most instances the atrophy is to be regarded as a passive process, the result of disease or disuse of the nerve or muscle. In some it is the exhausting result of excessive innervation in resistance to tonic spasm (Jeleuffy)—prolonged catabolism. On the other hand, similar conditions may exist for years without producing atrophy. The rapidity with which atrophy, notably of the posterior crico-arytenoid muscle (Semon), sometimes follows paralysis, renders it likely that an active neurotic degeneration has been in progress. Active neurotic atrophy presupposes injury to the spino-neural mechanism, or irritation of the afferent fibre of a reflex arc (Ross). The association of trophic with motor paralysis renders it impossible to determine whether or not the nutritive changes are under the domain of special nerve-supply. Some observations by Türck ("Klinik der Krankheiten des Kehlkopfes und der Luftröhre," p. 440, Wien, 1866) as to atrophy of the crico-thyroid muscle without degeneration of the superior laryngeal nerve, led him to the inference that the trophic supply of this muscle must have come from the recurrent nerve and not from its own motor nerve.

While all the muscles of the larynx are subject to atrophy, none are so prone to atrophy from pathological lesions as the posterior crico-arytenoids. Great atrophy of these muscles alone has been observed after paralysis, independently of any microscopic evidence of alteration of either recurrent or pneumogastric nerves, as in an instructive instance reported by Riegel (cited in Ziemssen's "Cyclopædia of the Practice of Medicine," vol. vii., p. 961, New York, 1876). In most similar instances, however, degeneration of nerve-tissue has coexisted. Similar atrophy of the posterior crico-arytenoid has been observed likewise in cases of spasm of all the laryngeal muscles, possibly because of the forced inaction due to its having been overpowered by the combined force of the antagonistic muscles; probably because of cessation in the organic exercise of its special function, or perhaps because of loss of innervation from the respiratory centre, through other channels than those proceeding from the fibres of the recurrent nerve. Atrophy of the muscle has been recorded, as far as I know, only in cases in which the corresponding vocal band had been in phonatory, or in approximatively phonatory, position during life.

Treatment.—There is no special treatment that can be pursued with confidence. Probably systematic and long-continued electrical treatment offers the most reasonable prospect of benefit.

Changes in Secretion.—There is little reason to doubt that changes in the secretory products of the glands of the mucous membrane are often troublesome, especially when occurring in neurotic subjects and in the absence of marked pathological change of tissue. They may be, and most frequently are, associated with hyperplasia of the gland tissue, of the connective tissue or of the epithelium, or they may be associated with conditions of malnutrition and atrophy.

In many instances these are due to retention of products impairing nutrition, the result of improper diet and hygiene, and lack of elimination and exercise. Purgatives, diuretics, and sedatives, regulated diet, work, exercise, and sleep will do far more good in these instances than any topical treatment.

HYPERÆSTHESIA. NEUROSES OF SENSATION.—The term sensory phenomena is too broad and may well be subdivided. Krishaber[1] made a distinction between common and reflex sensibility. Bosworth[2] discriminated between three kinds of sensibility: 1, tactile, by which temperature and pressure are appreciated; 2, dolorous, by which pain is appreciated; and 3, reflex, by means of which muscular contractions, such as occur in cough, spasm, sneezing, choking, etc., are provoked, as are vasomotor, [illegible] vascular and secretory phenomena. Still further subdivision seems requisite, however, to include all varieties of sensibility; for distinction can be made by sensation between touch, or tactile sensibility; temperature, or thermal sensibility; weight, pressure, and resistance, or muscular sensibility; pain or dolorous sensibility; and a group of manifestations of reflex sensibility.

Sensory neuroses may affect all of these conditions, or any one or more of them. The degree of sensory excitability varies within great limits, not only in individuals but in the same individual under different conditions, normal and abnormal. The normal degree of sensibility in any individual may be augmented, diminished, obtunded, or abolished under the influence of hygienic or of toxic surroundings, and of overwork, innutrition, exposure, injury, and disease. Disorders of sensibility, dysæsthesiæ in general, may be due to appreciable structural lesion, to inappreciable structural lesion, or to either a want or an excess of stimulation in tissues both structurally and chemically intact. The latter division comprises the group of lesions of function, without appreciable lesions of structure, to which the term functional neurosis is applied. Disorders of sensation, dysæsthesiæ, occur as simple and as complex manifestations. They occur as primary and as secondary disorders. Primary dysæsthesiæ present as augmented, perverted, or diminished sensations of touch, body temperature, titillation (the analogue of cutaneous pruritus, Rossi), weight in the parts or mechanical restraint, irritability, discomfort, and pain. Secondary dysæsthesiæ present themselves as phenomena produced in the course of various diseases or disordered conditions of which they become part of the regular clinical train of symptoms, and to which affections their study is best relegated. Absence of these diseases usually stamps the neurosis as primary. The diseases and disordered conditions referred to, include inflammation, abscess, tumor, presence of a foreign body, tuberculosis, syphilis, lupus, carcinoma, [illegible], paresis from whatever cause, and diffuse cerebral and cerebrospinal lesions.

If special names be given to the various conditions, in accordance with modern neurological nomenclature, their classification would be somewhat as follows:

1. Neuroses of tactile sensibility, comprising (a) augmented sensitiveness to the touch, hyperæsthesia; (b) perverted sensitiveness, paræsthesia, including abnormal sensations of numbness, discomfort, tickling, itching, burning, tingling, pricking, of constriction, and of the presence of a foreign substance; (c) diminished sensitiveness, hypæsthesia (Eulenburg); (d) abolished sensitiveness, anæsthesia, including the anæsthesia produced by applications with ice or with drugs, such as preparations of cocaine, carbolic acid, menthol, eucaine, and the like.

2. Neuroses of dolorous or pathic (Rossi) sensibility, comprising (a) augmented hyperirritability, pain, algesia; or augmented sensation to painful conditions, hyperalgesia or hyperalgia, including painful sensations caused by the dread of an anticipated touch; (b) perverted sensation, paralgesia, constrictions, dragging; (c) diminished sensation, hypalgesia or hypalgia (Eulenburg), including [illegible]; (d) abolished sensation, analgesia; (f) paroxysmal painful sensations along the course of a sensory nerve, neuralgia.

3. Neuroses of thermal sensibility, comprising (a) augmented sensitiveness to heat or to cold; (b) perverted sensitiveness, sensations of heat, of burning, scalding, melting, of intense cold; (c) diminished, and (d) abolished sensitiveness.

4. Neuroses of muscular sensibility, comprising augmented sense of weight in the parts or pressure upon them, or of mechanical restriction in moving them, altogether independently of any condition of motor paralysis, as when distinct excessive muscular effort is required for phonation in fatigue from overuse or prolonged use of the voice. All these conditions occur usually in association with diseases in which they form part of the clinical pathological group of symptoms. Some occur independently of appreciable disease, or with such prominence as to become the leading feature of the disorder. The latter group are all that need any consideration in detail under the head of neuroses.

Hyperæsthesia.—Augmented tactile sensitiveness, abnormal hypersensitiveness of the laryngeal mucous membrane, is quite frequent in both catarrhal and ulcerative inflammatory disorders of the larynx. It is often associated with hyperæsthesia of the palate or of the pharynx. It often occurs as a manifestation of hysteria; often as a reflex neurosis. It is sometimes associated with spasm in these structures, and often gives occasion to spasm of the constricting muscles of the larynx, or to sensations of spasmodic contraction which are always distressing and sometimes alarming. In some instances it alternates with conditions of anæsthesia and of paralysis (Lisker, Gougenheim).

In one class of cases the use of the voice produces pain, and in some of these instances the annoyance to phonation from the sensations excited becomes so intense as to deter the patient from all attempts at using the voice. This condition has been termed phonophobia (Coen).

In another class of cases a peculiar intermittent hyperæsthesia sometimes occurs after bronchitis, commencing with sensations of burning and tickling, which are followed by paroxysms of dry or of moist cough, culminating in spasm of the larynx, which, in its turn is followed by vertigo, or by actual loss of consciousness, and is sometimes attended with convulsions of the face and even of the upper extremities, presenting, in fact, the condition to which the term laryngeal vertigo (Charcot) has been given.

With the cessation of the abnormal sensation in the larynx, the vertiginous seizure ceases, and the ordinary [illegible] condition of the subject pursues its accustomed course.

Pathology.—It is not likely that neuritis is present. Hysteria exists in many instances; in others there is a gouty diathesis, and especially a disposition to asthma.

Etiology.—A highly neurotic temperament is the main remote cause of hyperæsthesia. Gout and rheumatism are likewise remote causes. The immediate causes are varied in character, and are sometimes direct, sometimes reflex. Irritation in any portion of the alimentary tract, from the mouth to the anus, or in any portion of the respiratory tract, from the nostril to the pulmonary alveoli, may act as an exciting cause, or may keep up an hyperæsthesia of different origin. It is often due to influences, direct or reflex, from small neoplasms, retained secretions at the orifices of glandular ducts, and from various minute ulcerations, excoriations, or fissures in the pharynx, base of the tongue, tonsils, palatine folds, uvula, palate, or the intranasal tract. In some instances certain spots on the neck are especially painful (B. Fraenkel).

Treatment.—Both constitutional and topical treatment are required. In excitable or irritable conditions of the nervous system, nerve sedatives, such as bromides, [illegible], cannabis indica, hyoscyamus and its derivatives, chloral, and antipyrin, are indicated; in hysteric conditions, preparations of musk, assafœtida, or valerian; in debilitated conditions, nerve and blood tonics, such as arsenic, iron, quinine, strychnine, or their equivalents; in gouty and rheumatic conditions, colchicum, salol, and the salicylates. The condition of the digestive apparatus and of the emunctories requires strict attention that assimilation of nutriment may be as complete, and elimination of effete products as thorough, as possible. The liver, the kidneys, and the skin should be maintained in active performance of their respective depurative functions as far as practicable. The medical discipline and the medicinal agents to be employed for these purposes will vary with special indications, and must be selected in accordance with the principles of general therapeutics.

Topically, soothing or benumbing applications to diseased or disordered tissues are indicated, repeated once or oftener a day. These may comprise applications of morphine, of bismuth, or of aconite, in glycerine or water; of iodoform in ether or chloroform; or of cocaine, of thymol, or of menthol; sprays of opium, of bromides, of chloral, or of camphor in simple water or in peppermint water; sprays of iced water; inhalations of vapors of benzoin and similar drugs, changes being made from time to time as indications vary.

Permanent mechanical, traumatic, and plastic lesions producing the hyperæsthesia require to be combated, destroyed, or removed, according to the special indications.

Paræsthesia.—Paræsthesia denotes a condition of perverted or abnormal sensation, diffuse or localized, quite different from sensations of pain. It is most frequent in hysterical females. It is most usually described as a sensation as though a hair or other foreign body were present, or a sensation of tickling, burning, tearing, itching, or something not unlike. These sensations are sometimes provoked by phonation, and to prevent them the sufferer becomes disposed to speak in whispers only (phonophobia, Coën). In some instances the sensations are limited to the larynx; in others they extend into the pharynx in the one direction, or along the trachea in the other. Tracheal extensions cause considerable mental anguish and dread of suffocation.

Localized paræsthesias are frequently referred to the regions connecting the anatomical structures of the larynx, or the structures adjacent, as the regions of the hyo-thyroid membrane, crico-thyroid membrane, glosso-epiglottic fold, crico-thyroid articulation, or crico-arytenoid articulation. Paræsthesia is sometimes combined with anæsthesia (Elsberg, B. Fraenkel), and is sometimes followed by it. It sometimes causes considerable hypochondriasis, from the patient's dread that some incurable disease is in progress.

Its etiology and pathology seem closely allied to those of hyperæsthesia, if not identical; and the therapeutic measures would be much the same as for that condition.

Anæsthesia.—Anæsthesia of the larynx is the term used to indicate serious loss of sensitiveness of the mucous membrane, whether partial or complete, comprising likewise hypæsthesia or obtunded sensitiveness. It sometimes alternates with hyperæsthesia (Gougenheim), and is sometimes associated with paræsthesia. It may, or may not, be associated with motor paralysis. In cases due to diphtheria, motor paralysis coexists. The motor paralysis may, or may not, be in the domain of the same nerve-trunk. It is most frequently manifested in the constrictor group; the subjective symptom being dysphonia or aphonia. It occurs both unilaterally and bilaterally. In intensity it varies both with the cause and with the individual. It varies at times, likewise, in the same subject. It also varies in extent. In some instances it is confined to the epiglottis; in some to the supraglottic portion of the larynx, while in others it occupies the entire larynx; the extent varying according to the degree of participation in the lesion of the sensory nerve distributed to the regions indicated.

Laryngeal anæsthesia may be isolated, or may be associated with anæsthesia of the trachea, of the pharynx, of the palate, or of other organs and structures adjacent, contiguous, or at a distance; the special association being dependent upon the pathological or etiological lesion. Tactile sense may be in abeyance naturally, or can be placed in abeyance artificially, as by repeated manipulation with instruments, and by applications of cocaine hydrochlorate, menthol, and some other drugs. This abeyance is often associated with abeyance of reflex excitability, or with sufficient impairment to place that excitability under control; but sometimes the reflex excitability continues, so that spasmodic contractions ensue under its influence despite abolition of the tactile sense. Contrariwise it is asserted (Brown-Séquard) that anæsthesia of the entire body can be produced experimentally by irritation of the laryngeal mucous membrane.

Pathology.—Structural change, whether demonstrable or not, in the region of the origin or nucleus of the pneumogastric nerve, or in the tract of its superior laryngeal branch, is presumed to constitute the pathology of gross anæsthesia occurring in association with diphtheria, with syphilis of the cerebrum, or in bulbar paralysis.

Interruption in the transmission of peripheral impulses to the cerebral centre is the presumptive pathological condition in the anæsthesia occurring in hysteria. Should the anæsthesia be found to be limited to the upper portion of the larynx, ceasing at the margins of the vocal bands, the productive lesion will be presumptively attributable to disorder in the tract or nucleus of the superior laryngeal nerve from which sensory fibres are distributed to this portion of the larynx.

Anæsthesia extending beyond the margin of the vocal bands will be similarly attributable to disorder in the tract or nucleus of the inferior laryngeal nerve; and the lesion will be referred accordingly to the trunk of the pneumogastric, above the departure of the superior laryngeal, to its nucleus, or to its point of origin.

Symptoms.—Liability to access of foreign matter into the larynx during deglutition is the most prominent symptom. Lack of sensation to titillation and to irritation, and lack of reflex response by cough to irritation are additional symptoms.

Etiology.—Anæsthesia of the larynx is usually indicative of deeper lesion. The two chief causes are widely different in character, being hysteria and diphtheria. Then, but far less frequently, follow the lesions of bulbar paralysis (Krishaber) and of cerebral syphilis (Ott*). Anæsthesia has been noted in the asphyxic stage of cholera (Romberg), and is similarly present at times during the death agony. Hysteria is a far less frequent cause of anæsthesia of the larynx, or at least of the epiglottis, than was generally supposed a number of years ago; the mistake having been due to want of recognition of the fact that the epiglottis is a far less sensitive structure in some subjects than in many others. An anæsthetic epiglottis cannot be regarded, therefore, as pathognomonic of hysteria.

Among other causes to which laryngeal anæsthesia seems to have been attributable may be cited, severe forms of sore throat, epilepsy, plumbism, alcoholism, syphilis, and even carcinoma and tuberculosis (Krishaber).

Anæsthesia from diphtheria is often associated with paralysis of the depressor muscles of the epiglottis which are innervated by the superior laryngeal, the same nerve which supplies sensation to the supra-glottic portion of the larynx. Paralysis of the crico-thyroid muscle, supplied by the same nerve, may, or may not, exist. In occasional instances there is paralysis also of some of the phonatory muscles, indicating implication of the inferior laryngeal nerve. Anæsthesia is sometimes associated with neuralgia (anæsthesia dolorosa) (Schnitzler, Elsberg).

Sequelæ.—Laryngeal anæsthesia, especially when complete, and associated with anæsthesia of the trachea, of the epiglottis, and of the pharynx, has been noted as a precursory formation of [illegible] laryngeal paralysis ([illegible], 1877, No. 48).

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* For a marked instance of right-sided anæsthesia in association with right-sided paralysis of the vocal band in the cadaveric position, in a case of extensive hereditary syphilitic disease, which had involved the origin of the vagus, from which all traces of medullary fibres had disappeared, thus destroying all communication with the larynx, centrifugal and centripetal, see Ott, Prager Med. Woch., 1881, No. 4.

Diagnosis.—Passage of food or drink into the respiratory channel, larynx, in the absence of motor paralysis and of mechanical lesions, such as morbid growth, wound, or foreign body, is presumptive evidence of anæsthesia. Palpation by probing or electric stimulation, however, under laryngoscopic inspection, is the proper method of making the diagnosis, and will reveal the intensity and extent of anæsthesia. Diphtheritic anæsthesia is usually associated with paralysis of the depressors of the epiglottis. Entire loss of sensitiveness will be indicated by absence of any sensation of touch, or of pain, or of any evidence of reflex movement. Partial sensitiveness may, or may not, be associated with voluntary suppression of the reflex movements of cough, and of spasmodic closure. The most sensitive portion, normally, is the internal or intra-laryngeal surface of the interarytenoid fold, the touching of which, with the probe, usually excites titillation and cough.

To determine whether apparent want of sensitiveness be abnormal, the mucous membranes of other structures, adjoining or at a distance, should be examined, for individuals will be found with general obtuse sensitiveness. Limited patches of cutaneous anæsthesia at the anterior portion of the neck, above and below the hyoid bone, have been indicated as frequent and peculiar concomitant signs of laryngeal anæsthesia.

Prognosis.—The prognosis will vary with the nature of the lesion. It is of the gravest character when present in association with bulbar paralysis. It is serious in all cases of central origin.

In diphtheria the prognosis is good provided that means are available during treatment to prevent the entrance of food into the larynx; an accident that may be followed by suffocation on the one hand, or by fatal pneumonitis on the other.

In cerebral syphilis the prognosis will be dependent upon the extent of the lesion, which will therefore be an unknown factor, unless amelioration follow the institution of antisyphilitic remedies.

The condition is always rendered serious in the presence of catarrhal inflammations, in which the product of secretion may accumulate in dangerous and even fatal quantity without exciting the reflex movements of cough for their expulsion.

Treatment.—The treatment will vary with the nature of the case. Preparations of phosphorus and of strychnine, or its equivalent, are usually indicated constitutionally. Induced electrical currents topically are often additionally serviceable in cases of diphtheritic origin.

Feeding by the œsophageal or even by the stomach tube is indicated when attempted deglutition drives food into the larynx. The condition of anæsthesia calls for especial care to see that the tube is not introduced into the larynx. It should be guided along a finger placed behind the epiglottis or at the entrance of the larynx, or should be introduced under laryngoscopic illumination. Hysterical anæsthesia is sometimes promptly relieved by the emotional influence of the laryngoscopic examination. It may subside under the influence of mere probing, of painting with silver nitrate or other reagents, or of the application of the electric brush, according as its intensity may warrant.

Constitutional syphilitic disease will require the usual constitutional antisyphilitic measures.

Sclerotic conditions of the nervous structures, and bulbar paralysis, must be met by the measures indicated by neurologists: internal administrations of silver nitrate, gold and sodium chloride, etc.

Hyperæsthesia.—Neuralgia of the larynx usually occurs in a series of paroxysmal darting pains of irregular recurrence, radiating from one side of the larynx, most frequently the left, or from both, to the ear. Similar pains occur in cases of ulceration of the epiglottis, and in some unrecognized cases of syphilis and carcinoma.

Sensations of tickling from irritation of the terminal filaments of the sensory fibres of the pneumogastric, and especially of those of the superior laryngeal division, leading to reflex irritative laryngeal cough to relieve them, are not to be regarded as evidences of neuralgia.

The treatment is constitutional, as for all forms of neuralgia.

KINESIONEUROSES.—These comprise the groups, hyperkinesis (spasm), and akinesis (paralysis).

HYPERKINESIS.—*Spasm of the Larynx. Laryngismus.*—Spasm of the larynx is a spasmodic closure of the glottis by contraction of all the constrictor muscles, or of all the muscles of the glottis, both constrictor and dilator, the predominant effect by the dominance of the constrictors producing closure just as surely as though the dilators were unaffected. The latter condition is sometimes mistaken for paralysis of the dilators.

Spasm of the constrictor muscles of the glottis is sometimes associated with paralysis of the dilator muscles, the contracture following the paralysis. Spasm of individual muscles also occurs in which the constriction of the glottis does not take place.

Spasm of the larynx occurs in three forms: tonic or fixed, clonic or mobile, and contractile or [illegible]. The spasm is respiratory in some instances, phonatory in others. The respiratory spasm may follow either the expiratory or the inspiratory phase, the latter variety being usually the severer. Inspiratory spasm is familiar to all who have practised initial cauterization upon the interior of the larynx. This manipulation produces a series of painful stridulous inspirations through a glottis that has become spasmodically closed; the expirations remaining efficient, noiseless, and free from cough. The spasmodic phenomena subside in a few minutes, although the pain from the cauterization continues. An expiratory spasm occurs when a foreign substance enters the larynx suddenly, as when a drop of water goes the wrong way during speech or laughter. The spasm, at first often inspiratory as well, is essentially an expiratory, stifling spasm of cough; and the cough continues until the foreign matter has been expelled, or until the uncomfortable sensations it has produced have in a great measure subsided. These examples, while serving to illustrate the phenomena of spasm, do not enter into the category of essential neuroses.

One form of spasm, a true laryngismus, occurring during a paroxysm of cough which has been spontaneously provoked by tickling or other abnormal sensation in the larynx, is marked by sudden arrest of the muscles of respiration, with dizziness or vertigo, and partial or complete loss of consciousness for a few seconds, so that the patient may fall to the ground if erect. Consciousness returns in a few seconds, and the patient is usually as well as ever, without stupor or other morbid symptoms. The term laryngeal vertigo (Charcot) has been ascribed to this variety, but it appears to me without sufficient reason, inasmuch as giddiness or even momentary loss of consciousness is not rare after prolonged coughing spells, and occasionally attends prolonged efforts of forced expiration during auscultation of the lungs. This form of laryngismus occurs far more frequently in males, and after middle life, and in individuals who are gouty, or who are the subjects of asthma and bronchitis. Convulsive movements of the limbs and of the face have been noted in some instances. The attacks may occur at irregular intervals of days, weeks, or months, or as frequently as several times a day.

Spasm with aphonia occurs occasionally as a professional hyperkinesis in persons who have been compelled to make great use of the voice. While the muscles respond normally in respiration and in voluntary efforts of expiration and inspiration, in coughing and in laughing, spasm occurs, as in histrionic spasm, writers' cramp, and so on, whenever an attempt is made to use the muscles for phonation, and the act becomes impracticable. To this condition the term spastic aphonia (Schnitzler) has been applied.

Fatigue of the cerebral centres has probably been produced, so suppressing their functions as to develop a latent contracture of the muscles in connection with them, which becomes augmented into spasm when the power centre in the medulla is put into action as in the explanation given (Hughlings Jackson) for writers' cramp; which is, that the lower centres, being in a condition of "hyperphysiological activity," are "let go," just as the spinal centres are, in hemiplegia, accompanied by slight rigidity.

When the individual attempts to speak, a spasmodic hypercontraction of the muscles of phonation brings the vocal bands into such close approximation that the phonatory current of air cannot pass between them.

Aphonia spastica has been found associated with dyspnœa, as in a very interesting instance described by Michael ("Aphonia und Dyspnœa Spastica," Wiener Med. Presse, 1885, Nos. 41 and 42). In this patient, a married woman, thirty-two years of age, with hysteria, there were in addition globus hystericus, muscular contractures of the face and of the extremities, intercostal neuralgia, and occasional paroxysms of hystero-epilepsy. The diagnosis was made during narcosis preliminary to tracheotomy, when subsidence of the spasm, restoration of free respiration, relief from cyanosis, and resumption of voice occurred. Return of the spasm, as consciousness revived, rendered the tracheotomy imperative. It was necessary to retain the cannula permanently, no change in the laryngeal neurosis having taken place at the date of the report, three years after the operation.

Hysterical spasm may manifest itself in the inspiratory or in the expiratory phase of respiration, or in both phases. Inspiratory spasm is characterized by stridor, feebleness of voice, and shallow respiration.

Expiratory spasm is phonal, and is characterized by a series of convulsive barking or other explosive coughs repeated many times a minute; continuing many minutes or hours during the day, and recurring daily for many days, months, or even years. It is not manifested during sleep. The term laryngeal chorea has been given to this variety of spasm, owing to the irregular or choreic movements of the vocal bands during the attack; a term which should be confined to such laryngeal choreic movements as are associated with genuine chorea (Schreiber).

Pathology.—Spasm of the larynx in the adult occurs as a result both of direct and of reflex irritation. Chronic hyperæmia of the larynx, ulcerations of the mucous membrane, morbid growths, or foreign bodies may be the source of direct irritation. In these cases spasm of the larynx is a symptomatic feature merely—sometimes of serious and even of fatal import.

It exists also, occasionally, as a true neurosis in disease of the nerve tissues or tracts. It is often one of the early symptoms of locomotor ataxia (Fereol), and sometimes for a long period is the only premonitory symptom of that affection (Krishaber). It occurs likewise in ascending spinal sclerosis, in multiple neuritis, in hysteria, and in hystero-epilepsy, though rarely in true epilepsy; it has been observed in the subjects of hydrophobia, plumbic poisoning, and of pressure of various kinds upon the pneumogastric and recurrent nerves; and after inhalations of irritant gases, prolonged sojourn of foreign bodies, the titillations of pedunculated laryngeal neoplasms, and in œdema of the larynx. The vertiginous form of the affection has been attributed to some peculiar irritation of the centripetal laryngeal nerves (Charcot) and to epilepsy (Gray). It has been excited by intranasal irritation from a polyp (Knight). Knight attributes the vertigo to direct disturbances of cerebral circulation by compression of the large vessels, and even of the heart, in consequence of forced expiration against a glottis closed in spasm. It is probable that constant cough may produce turgescence in the cerebral arteries which have undergone or are undergoing the usual changes which occur after the age of forty.

Symptoms.—Sudden dyspnœa with laryngeal stridor are the main symptoms of bilateral spasm. They relax in clonic spasm, and are more or less continuous in tonic spasm. Unilateral spasm is often unattended with subjective symptoms, unless there is exertion of some kind.

Etiology.—Functional spasm may be attributed to molecular changes unassociated with structural disease, and therefore without any objectively perceptible lesion.

Organic spasm may be due to changes in the nerve-centre, especially in the nucleus of the pneumogastric or of its superior laryngeal division. It may be due to compression of the superior or of the inferior laryngeal, or the pneumogastric nerves by an abscess, enlarged glands, or morbid growths. Compression thus occasioned, especially when neuritis is present, will sometimes produce spasm, with occlusion of the glottis by bilateral action, even though the compression involve one nerve only.

Reflex spasm may be occasioned by irritation in the nasal or in the pharyngeal mucous membrane, the external auditory meatus, or in more distant mucous membranes, or in ovarian irritation.

Diagnosis.—This is based on the sudden dyspnœa and stridor. The condition is recognized in the laryngoscopic image by approximation of the vocal bands when bilateral, and sometimes by approximation of the ventricular bands. The arytenoid cartilages are drawn backwards, a position which serves as a discriminating feature from bilateral paralysis of the dilators (Jeleuffy). In unilateral spasm the vocal band is drawn to the middle line or the phonatory position.

Prognosis.—Life may be lost in an initial bilateral spasm. Should the spasm relax the prognosis will depend upon the curability of the exciting cause. Unilateral spasm is not menacing to life, unless for some reason the sound side should become subsequently involved.

Treatment must be directed not only to the spasm but to the constitutional malady underlying it. Rest—physical, mental, and emotional—is an important element in the treatment. All sources of excitement must be avoided. Systemic remedies suited to the malady are to be employed, to which antispasmodics should be added with sedative inhalations. Topical treatment is imprudent, and is liable to excite spasm during moments of quiescence, or to increase it when in progress. Inhalations of chloroform or of amyl nitrite may be employed during moments of exacerbation. In cases of continuous tonic spasm, and of frequent clonic spasm, tracheotomy is indicated either as a permanent therapeutic measure or as a prophylactic one. Its performance becomes imperative in the presence of even moderate inflammatory swelling.

Laryngismus Stridulus—spasm of the laryngeal muscles in infants—*Clinical History.*—A child with impaired nutrition, and in most instances a subject of craniotabes (Elsässer), especially when the affection begins during the first year of life, is suddenly seized with an alarming arrest of respiration, most frequently in its expiratory phase, and is unable to get his breath. The seizure may occur while the child is awake, whether he be quiet or excited, or it may awaken the child from sleep by day or by night. In from ten to twenty seconds, sometimes not until after the lapse of sixty or more, a prolonged shrill crowing or stridulous inspiration takes place, and respiration becomes re-established; a spell of crying or coughing, or both, usually following. The attacks are slight in many instances, severe in some, and occasionally are immediately fatal by apnœa.

Mild attacks frequently occur without exciting alarm or even attention. In cases of severity the attacks may recur at intervals of a few hours or of a few days during a period of several weeks or of several months. They sometimes recur with gradually increasing frequence, in some instances with gradually increasing severity also.

Pathology and Morbid Anatomy.—While cases occasionally occur as examples of a special neurosis, the majority are of reflex origin. Some of these are due to irritations of the trifacial nerve in dentition, of the pneumogastric in malnutrition, and of the spinal nerves in intestinal disorders (Marshall Hall). Some are due to irritation from enlarged scrofulous glands along the tracheo-bronchial tract, and along the tract of the pneumogastric nerve and its subdivisions. The majority are due to craniotabes (Elsässer) in rachitis, a condition in which hyperæmia of the meninges or of the encephalon is readily produced by fits of laughing, crying, holding the breath from fright, and other slighter causes of exditions. Congestion and thickening of the meninges have been observed in the dead subject, but by no means frequently. Similarly, changes in the consistency of the pneumogastric nerves have been sometimes noted, as well as caseous degeneration of the bronchial glands. The condition of the thymus gland, to which much importance was formerly attached, has been found so variable as to eliminate disease of that structure from special pathological significance. No special lesion has been traced in the larynx.

Symptoms.—The characteristic symptom is sudden, spasmodic dyspnœa, terminating in relaxation from spasmodic closure of the glottis with a reëstablishment of respiration at the end of ten or more seconds after one prolonged, sibilant, crowing inspiration, or after a succession of shallower ones, unaccompanied by expiration. During the attack the face is first pale, then flushed, and finally livid or cyanotic. The limbs are cold, the head is thrown backward, and the mouth is open, or gasping for breath, as it were. The patient may grasp at the throat as though to tear away some obstruction, or the extremities may lie flaccid or stiff. In severe cases there are convulsions of the diaphragm and of the intercostal muscles, and even of the extremities.

Etiology.—The remote causes of the affection reside in the constitutional condition; the immediate ones in the irritability of the nervous system and in the exposure to irritation of the sensitive surfaces from which the reflex manifestation is started. Rachitis is by far the most common of the remote constitutional causes, and the more acute this disease the more frequent are the paroxysms. Scrofulous affections, particularly enlargements of the lymphatic glands along the course of the pneumogastric nerve and its subdivisions; imperfect nutrition and lack of proper hygienic conditions are other remote factors. Irritation of the mucous membranes in the mouth, throat, and intestinal portions of the alimentary tract are the more immediate factors. These favoring conditions being present, slight excitation may provoke the paroxysm; anything, in fact, which frightens the child or disturbs its equanimity; in patients of great nervous irritability even the dread of a touch.

The age at which the affection is most frequent comprises the period between the fourth and twenty-fourth month. It has been observed in the new-born child and in children from three to eight years of age. Boys are far more subject to it than girls. It is most frequent during the cold and wet season of the year, and more frequent in northern than in southern latitudes.

Diagnosis.—This is easy, and is based on the sudden onset of the paroxysm, the stridulous character of the respiration, the cyanotic condition, the attendant spasms elsewhere, and on the freedom from evidence of laryngeal disorder in the intervals between the paroxysms.

Prognosis.—The prognosis must be guarded in almost all instances, for quite a large proportion of cases terminate fatally during a paroxysm. It has been estimated that nearly one-third of all cases perish in this way. The older the child, the slighter the paroxysm, the milder the complications, the better the nutrition and surroundings, and the more amenable to treatment the constitutional disease under which the patient is laboring, the better the prognosis. Treatment is often protracted, this depending chiefly on the general health of the patient and the hygienic character of his surroundings.

Treatment.—An attack of laryngismus having been recognized, the treatment will be prophylactic to ward off future paroxysms as far as practicable, and corrective as regards the causal factors. Little can be done during a paroxysm, as the attack usually subsides before any remedy can be given. The child must be raised at once, and its head be bent backward to facilitate respiration, by placing the airway in the most favorable position. Efforts are to be directed to relax the glottis and avert suffocation. Various methods are recommended, any one of which there is usually time to execute. These comprise dashing cold water upon the face, loosening all constricting clothing, flagellation to the trunk and extremities, passing the finger into the larynx to release or to mechanical appliances to provoke gagging, tickling the nose (Sneezing) so as to force an involuntary effort at respiration, seizing the tongue and pulling it forward. If time permit, chloroform may be passed before the mouth in hopes that a few whiffs may be inhaled and thus relax the spasm; but usually there is no time to secure the chloroform, far less to prepare a hot bath, as is often suggested. Immediately after the paroxysm has subsided, efforts should be directed toward allaying any irritation or source of irritation that may exist in the mouth, stomach, intestines, anus, vagina, prepuce, or elsewhere. The prophylactic treatment against future paroxysms will consist in the administration of bromides, chloral, camphor, asafœtida, or musk, according to the preference or experience of the physician, or the special indications. The corrective treatment of the causal condition will include proper attention to diet, clothing, ventilation, sleep, exercise, and general hygienic surroundings; with the internal administration of cod-liver oil, malt extract, ferrous iodide, or potassium sulphate, as indications may dictate. Suitable appliances should be kept at hand to carry out whatever procedure may be selected as the most appropriate to execute during any future paroxysm.

Should the attacks of laryngismus become frequent and increase in severity, tracheotomy may become necessary in order to secure an avenue for respiration through the artificial opening during the closure of the glottis. The cannula having been introduced, the patient must not be allowed to go about without the tube as long as any disposition to spasm remains. An unnecessary loss of life has been the penalty of disregarding this precaution.

AKINESIS.—*Paralyses of the Larynx.*—Under the head of paralyses of the larynx it is necessary to include all impairments of motion, whether neurotic, myopathic, or mechanical in origin; as it is often difficult, and sometimes impossible, to distinguish them by their laryngoscopic image; and post-mortem examination sometimes fails likewise to show any anatomical lesion to indicate whether a paralysis has been neurotic or myopathic in origin. In many cases the distinction can be made only after microscopic examination of the nerves and muscles, and in some instances not even then. In some cases paralysis of the laryngeal muscles is unassociated with paralysis elsewhere. In many it is associated with paralysis elsewhere, and presents itself as one phenomenon only of the disease by which it has been produced. As already mentioned, paralysis is sometimes associated with the other neuroses.

Lesions of the nerve-nuclei usually produce bilateral paralysis on account of the close proximity of the origins of the nerves; and central lesions and derangements generally are likewise usually productive of bilateral paralysis. Lesions of the nerve-tract are commonly unilateral in their effects; but when a lesion is of great extent, as a large aneurism, or when it is multiple, as in some instances of morbid growth and aneurism, the two tracts on the two sides may become involved and the paralysis become bilateral.

Paralyses of individual muscles, of two or more muscles, and of groups of muscles, occur unilaterally and bilaterally as effects of lesions apparently limited to them; and also of lesions attributable, as far as is known, to myopathic causes only.

Pathology.—In myopathic paralyses the paralyzing disorder, whether disease or injury, is located in the muscular apparatus. Disease or injury to the centre or tract of innervation of the laryngeal muscles is the essential pathological feature of neuropathic paralysis. Secondarily degeneration of the muscles may follow, so that paralysis may remain from that cause even though recovery may take place from the neural lesion. This degeneration, when the result of disease, is most frequent in the posterior crico-arytenoids (Semon). The pathological lesions may involve the cerebrum, the medulla, the pons, the cord, or the trunks of the spinal accessory, pneumogastric, superior laryngeal, or inferior laryngeal nerves, or their peripheral filaments. When the central lesion extends beyond the nuclei of the laryngeal nerves there will be paralyses of muscles and organs innervated from the entire seat of the lesion, and thus of the tongue, face, lips, palate, pharynx, trapezius and sterno-cleido-mastoid muscles. The muscles of the eyeball and the muscles of the extremities may be paralyzed likewise, according as the lesion has implicated the roots or nuclei of the nerves distributed to the regions involved. Even the olfactory, ophthalmic, and auditory nerves have been implicated in very extensive lesions.

Laryngeal paralysis is less common in cerebral disease than are paralyses in other regions, a fact familiar in the clinical history of ordinary hemiplegia. This is accounted for, according to Broadbent, by reason of a relative immunity from paralysis possessed by muscles bilaterally associated in their action, because the muscles of each side are connected anatomically with the cortical centres in both cerebral hemispheres, and thus a compensatory nervous influence performs the duty on the two sides when one side is diseased.

A lesion of the recurrent should affect all the laryngeal muscles except the crico-thyroids and the depressors of the epiglottis, their further relations being identical. But the constricting muscles are phonatory muscles. They are not necessary for respiration and they are for phonation; hence, neuropathic paralysis affecting them alone implies a lesion beyond the origin of the recurrent trunk in the accessorius nucleus—at the phonic centre or in the tract leading from the centre to the nucleus. In hysterical paralysis, a molecular disturbance preventing passage of the will-current, there will be inability to will to phonate, and hence paralysis of the muscles of adduction.

When bilateral paralysis follows a unilateral lesion, the sensory fibres of the pneumogastric or of the superior laryngeal convey the peripheral irritation to the nucleus, whence in consequence of the crossing of nerve-fibres, the motor centres on both sides may become affected (Johnson). Hence, if the inferior laryngeals be purely motor nerves, injury to one recurrent alone cannot be productive of paralysis on the other side, inasmuch as the effects of injuries to motor nerves can be transmitted toward the periphery only. Any instance to the contrary would be proof presumptive that the recurrent nerve contained sensory as well as motor fibres. This is maintained to be the case by some observers, who contend that this nerve supplies sensation to the subglottic portion of the larynx and to the trachea. It has been claimed, however, that such sensory fibres may be derived from the superior laryngeal nerve through the communicating branch. Thus laryngeal paralysis occurs as a phenomenon of a number of diseases. It is occasionally congenital. When of central origin, it is most frequently observed in diseases of the medulla oblongata and of the pons, as in bulbar paralysis and progressive muscular atrophy, which Kussmaul, Charcot, and others have maintained to be identical; in multiple or disseminated cerebro-spinal sclerosis; in locomotor ataxia, and in general paralysis of the insane.

It is occasionally observed in other diseases and in disorders of the cerebrum, such as occur in apoplectic hæmorrhage, epilepsy, general neuroses, and especially hysteria, in syphilitic lesions of the cerebrum, in malignant and other morbid growths, and in ectasia of the blood-vessels. It occurs in diseases and injuries of the trunk of the pneumogastric nerve or of its spinal accessory reinforcement, or of the subdivisions of the nerve, the superior and inferior laryngeals. In some of these instances the lesion has been very high up, even within the skull, as in malignant growth involving the posterior fossa and the foramen lacerum (Türck).

Aneurism of the arch of the aorta, compressing the recurrent nerve, is the most frequent lesion producing paralysis of the laryngeal muscles. Compression of the recurrent or the pneumogastric likewise occurs from aneurism of the innominate and subclavian arteries, and compression of the pneumogastric may occur in aneurism of the carotid (Mackenzie). In these lesions the nerves being stretched, as well as compressed, and adhesions being often formed, it is difficult to determine the exact mechanism of the paralysis. One and the same lesion may compress both the recurrent laryngeal and the pneumogastric nerves. Occasionally bilateral paralysis is produced by separate aneurisms.

Similar compressions occur from enlarged thyroid gland, enlarged cervical and tracheo-bronchial lymphatic glands, and malign growths of these structures; malign growths of the neck, of the pharynx, of the œsophagus, and of the mediastinum, carcinoma of the œsophagus being the most frequent. Pericardial effusion, pleuritic effusion, chronic pleuritis, chronic pneumonia, and tuberculosis are cited as occasional causes of compression. In these lesions chronic neuritis of the injured nerve, with atrophy and degeneration, is the usual result, and degeneration of the muscles often ensues.

Traumatic lesions are occasional causes of paralysis by injury to the nerve. These include gunshot, punctured, and operation wounds, inclusion of the nerve in a ligature thrown around the adjacent artery, hypodermic injections, interstitial injections into tumors, infiltrations with blood or serum after contusions, and pressure or injury from a foreign body in the pharynx, œsophagus, or larynx.

Toxic paralysis occurs in poisoning by lead, opium, belladonna, stramonium, and cannabis indica. Septic paralysis sometimes occurs in infectious diseases, as in diphtheria, enteric fever, relapsing fever, cholera, variola, pertussis, erysipelas, dysentery, syphilis, tuberculosis, and malaria.

Paralysis occurs in various diseases of the larynx, including superficial or catarrhal laryngitis and perichondritis, and in inflammations from operative procedure, including tracheotomy. It may be produced also by the pressure of a foreign body within or outside the larynx, or as a result of the destruction of tissue by trichinæ or by overstrain from loud and continued singing and shouting. It sometimes proceeds from colds producing a rheumatic paralysis directly; and sometimes from mental excitement or emotion. Reflex paralysis occurs in some cases of disease of the nasal passages, pharynx, tonsils, intestinal tract, genito-urinary tract, uterus, and ovaries.

Rheumatic paralyses are presumed to be due to peripheral neuritis or to other disorders in the terminal nerve-filaments, occurring as the direct result of exposure to lowered temperature, or to fatigue in use of the muscles when infiltrated with the products effused during catarrhal laryngitis from similar exposure. In an instance narrated by Holz (Semon's notes to the German edition of Mackenzie) there was a rheumatic paralysis of the spinal accessory nerve alone, as shown in relaxation of the right trapezius and sterno-cleido-mastoid muscles, deviation of the uvula to the right, relaxation of the right half of the soft palate, and immobility of the right vocal band in nearly the median position.

Degenerations or other changes in the nerve-tract are sometimes not noticeable, although considerable impairment of function had been noted in the muscular territory of its distribution, and although degeneration of the muscle had ensued from the injury to the nerve. Degeneration of muscle also occurs independently of any appreciable lesion which could exert a deleterious influence on the nerve-supply. In these cases it is not improbable that peripheral changes exist which elude detection.

Symptoms.—The symptoms of paralysis of the laryngeal muscles consist in modifications in the functions of voice, cough, respiration, and deglutition. The voice is abolished in complete bilateral paralysis of all the muscles of the larynx, in bilateral paralysis of all except the crico-thyroids, paralysis of the recurrents, which is by far the more common, and in bilateral paralysis of the adductor groups only. In paralysis of the crico-thyroid muscles, paralysis of the superior laryngeal, the voice is tremulous and uncertain through lack of tension of the vocal bands; and it is harsh and deep, with inability to produce tones high in pitch. In some instances of hysterical paralysis of the adductors, the singing voice is unimpaired though the speaking voice is abolished. In the unilateral paralyses the voice is muffled, hoarse, or thrill, according to the muscles affected, the tendency of the sound side being able to force the corresponding vocal band beyond the median line so as to approach the paralyzed or immobile band sufficiently to produce vocal sounds. In unilateral paralysis of the recurrent laryngeal, the character of the voice in some instances will vary with the position of the head and neck. In some cases there is no modification of voice. Phonal cough is usually impaired in complete bilateral paralysis of all the muscles, and in many instances of complete unilateral paralysis. Approximation of the ventricular bands is sometimes observable, and this suffices for cough. It can be produced in nearly all cases of paralysis of the adductor groups of muscles only, which are due to hysteria. It is normal in complete paralysis of the abductor muscles whether unilateral or bilateral. In irritative lesions of the pneumogastric nerve spasmodic cough is often a characteristic manifestation. Inspiration is difficult and accompanied with stridor in complete bilateral paralysis of the abductors. Moderate stridor occurs on deep inspiration and on great physical exertion in complete bilateral paralysis, and to a less degree in unilateral paralysis of an abductor muscle. There is, of course, no stridor in paralysis of the adductors. Expiration is difficult on exertion in bilateral paralysis of the abductors, but is not impaired in the other forms of paralysis. Deglutition is difficult in paralysis of the depressor muscles of the epiglottis, food and drink falling into the cavity of the larynx from lack of closure of the vestibule by the epiglottis, which remains erect or semi-erect. Cough is thus excited to expel the foreign matter.

Etiology.—Neuropathic paralyses of the larynx are due to disease or injuries to the nerve-paths of the pneumogastric and spinal accessory nerves, to their branches, superior, median (Exner), and inferior laryngeals, or to their terminal filaments after their separation from the main trunks. The character of the initial lesions that produce the changes in the nerve-tissue which cause the paralysis has been discussed under the heading of Pathology. While anatomists are mainly in accord in the opinion that all the motor fibres innervating the laryngeal muscles proceed from the spinal accessory; that the superior laryngeal division of the pneumogastric supplies motor innervation to the crico-thyroid, and to the aryteno- and thyro-epiglottic muscles, and that the inferior or recurrent laryngeals supply motor innervation to all the other muscles of the larynx, it must be borne in mind that recent researches of German investigators, as well as some clinical observations (Türck, Dehio, etc.), point to the fact that the various muscles are often supplied by both laryngeals, and that the muscles of one side are often innervated by nerves from two sides. Hence, probably, arises much of the obscurity evinced in certain interpretations of paralyses of the larynx as revealed to laryngoscopic inspection.

Destruction of the nucleus of the spinal accessory nerve in the medulla, or of the continuity of the trunk of the pneumogastric above the point at which the laryngeal nerves separate from it, paralyzes all the muscles of the larynx of that side; and immobility of the corresponding vocal band, with relaxation of tension in the ordinary cadaveric position, follows.

Destruction of the continuity of the superior laryngeal nerve, or of its motor (the external) branch, paralyzes the crico-thyroid muscle of that side, producing impairment of the longitudinal tension of the corresponding vocal band in phonation, and depression in level, rendering its edge elliptically concave, and impairing its vibration in phonation. It also paralyzes the aryteno- and thyro-epiglottic muscles, so that active depression of the epiglottis is prevented or impaired.

Destruction of the continuity of the inferior laryngeal nerve paralyzes all the muscles of the larynx of the same side except the crico-thyroid and the thyro- and aryteno-epiglottics, so that the corresponding vocal band becomes immobile in the ordinary cadaveric position as in paralysis from similar lesion in the upper portion of the trunk of the pneumogastric. The unimpaired crico-thyroid is unable to contract from lack of fixation of the arytenoid cartilage, and hence presents no objective indication of its integrity.

Destruction of the filaments proceeding from the laryngeals to the various muscles produces paralysis of the muscle or muscles to which they are distributed. Peripheral neuritis will likewise produce paralysis of limited regions. Myopathic paralyses are due to changes in the muscular apparatus by infiltration, thickening of connective tissue, or otherwise. It is extremely difficult in many instances to separate myopathic lesions from neuropathic ones; and in some instances of apparently myopathic lesion it is safe to infer that peripheral neuropathic lesion exists also.

Diagnosis.—While the significance of laryngoscopy is nowhere more beautifully demonstrated than in the diagnosis of paralyses of the laryngeal muscles, great discretion is often necessary in interpreting its revelations. The two sides of the larynx may be normally asymmetric. The normal positions of the vocal bands in rest and in all phases of function are by no means alike in all subjects. Even the normal cadaveric position is not uniform after death, and hence the pathological cadaveric position cannot be uniform during life.

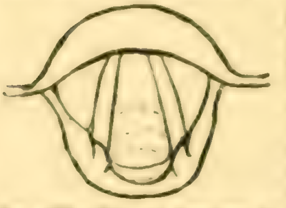

FIG. 4957.—Bilateral Paralysis of the Recurrent Nerve. [illegible]

The subjective symptoms in some instances are sufficient to indicate the existence of paralysis and its character.

Accuracy in diagnosis is secured only by inspection of the laryngoscopic image. The association of paralyses in other regions, and the symptoms of the case with its clinical history, serve to differentiate the disease or injuries which give rise to similar images.

In complete paralysis of the recurrent nerve, the vocal bands are relaxed in the position which is observed in the dead subject, the cadaveric position (Fig. 4957), and no movement takes place in respiration or in attempted phonation, although the crico-thyroids are not paralyzed; for these muscles are unable to render the vocal bands tense unless their posterior attachments to the arytenoid cartilages can be fixed in position by the action of the posterior crico-arytenoids. There is also anæsthesia of the subglottic portion of the larynx.

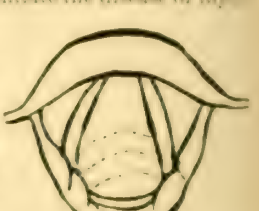

FIG. 4958.—Left-sided Recurrent Paralysis; Deep Inspiration.

In unilateral paralysis, the vocal band of the affected side will remain immovable or nearly immovable in the cadaveric position, but the vocal band of the sound side will move normally in respiration (Fig. 4958), in phonation (Fig. 4959), and in cough, and will even pass the middle line in phonation so as to come sufficiently near the immobile band to produce vocal sound. The action of the unparalyzed half of the arytenoideus muscle will in some instances produce slight motion or tremor in the posterior portion of the vocal band, or bring the tips of the arytenoid cartilage toward the sound side. In some instances the tip of the arytenoid cartilage of the sound side will be drawn in phonation beyond the median line and in front of the corresponding structure on the paralyzed side, thus giving the glottis an oblique direction toward the paralyzed side from before backward (Fig. 4960).

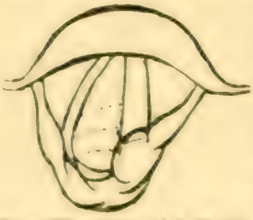

FIG. 4959.—Unilateral Paralysis of Recurrent. Phonation.

The anæsthesia of the subglottic portion of the larynx will be unilateral. Marked longitudinal relaxation of the vocal bands indicates, in addition, paralysis of the superior laryngeal innervating the crico-thyroids, and the lesion is located at a point anterior to that at which that nerve leaves the trunk of the pneumogastric.

Bilateral paralysis of the adductor groups of muscles will be indicated by continuous gaping of the glottis, with little or no motion, in respiration or on attempted phonation (Fig. 4961). In slightly paretic cases there will be initial approximation with sudden recession before phonal proximity is accomplished.

In unilateral adductor paralysis, which is exceedingly infrequent, the vocal band of the paralyzed side will remain at the lateral wall of the larynx, while the movements of the other will remain practically unimpaired.

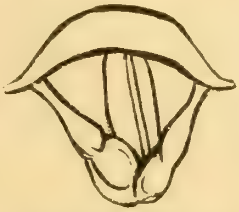
Fig. 4960.—Paralysis of Left Recurrent. Phonation with Crossing of Supra-arytenoid Cartilages.

Bilateral paralysis of the abductor muscles is recognized by the permanent location of the vocal bands quite near to the middle line (Fig. 4962), or at some point between that line and the lines of the cadaveric position. From this position they do not recede on the strongest effort of inspiration. On the contrary, they become more closely approximated and pushed downward by the atmospheric pressure of the inspiratory current of air, so that every inspiration is rendered prolonged, loud, and stridulous. The mucous membrane sometimes is forced down over and beyond the structure of the vocal bands. On expiration, the vocal bands are thrust upward and aside by the expiratory current of air, enlarging the elliptic or triangular orifice, so that expiration is comparatively quiet and easy. The physical signs of intense dyspnœa are present; sometimes to an alarming extent after exertion or agitation. This is especially prominent in a group of cases in which the vocal bands are nearly or actually in contact at the posterior vocal processes; conditions attributed to spasm of both abductors and adductors, or to secondary contractures of the adductors. The vocal bands then occupy the position for phonation. Phonation requires fixation of the arytenoid cartilages by the posterior crico-arytenoids, before the crico-thyroids can stretch the vocal bands (Jelenffy).

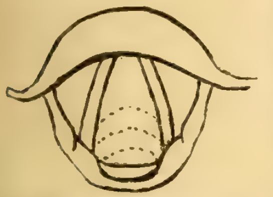
Fig. 4961.—Bilateral Paralysis of Adductors.

Voice is unimpaired, inasmuch as the vocal bands are continuously in a position to favor the action of their unparalyzed tensors. Immobility from spasm, from mechanical restraint by morbid growth, or from false or true anchylosis of the crico-arytenoid joint, must be carefully discriminated when practicable. Differentiation is often difficult, and its solution is dependent upon other manifestations than those observed in the laryngoscopic image. Sudden onset of the inspiratory dyspnœa, and temporary relief under anæsthesia, are both indicative of spasm, and may usually be relied on in differentiation, except in cases of contracture of very long standing, and in which other mechanical factors are present. Spasm due to compression of the nerve does not relax under anæsthesia.

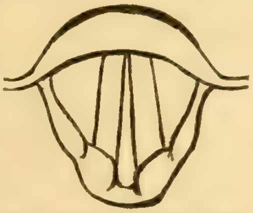
Fig. 4962.—Bilateral Paralysis of Abductors.

Unilateral paralysis of an abductor (posterior crico-arytenoid muscle) is recognized by the unilateral position of a vocal band, as indicated in Fig. 4963), and its immobility in inspiration. In the absence of any subjective symptoms it may exist for a long period without detection.

Paralysis of the depressor muscles of the epiglottis, the thyro- and aryteno-epiglottics, is indicated by erection of the epiglottis, which does not become depressed under attempts to perform so much of deglutition as can be accomplished with the mouth open. Its most frequent cause is diphtheria, and it is associated with anæsthesia of the supra-glottic portions of the larynx. The paralysis is attributed to lesion or disorder of the superior laryngeal nerve.

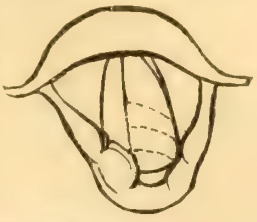
Fig. 4963.—Right-sided Abductor Paralysis. Deep Inspiration.

Paralysis of the crico-thyroid muscles is shown in marked cases only by lack of longitudinal tension of the vocal bands in phonation, efforts at which usually produce some congestion. Sometimes irregular undulation of the surface is seen. In most instances laryngoscopy shows no abnormal condition, and the diagnosis is inferred from the character of the voice and the absence of vibrations on palpation of the crico-thyroid membrane.

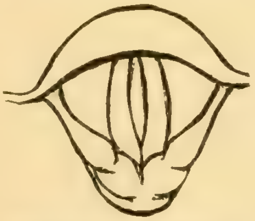
Fig. 4964.—Bilateral Paralysis of Thyro-arytenoids; Phonation.

This paralysis is due to lesion of the superior laryngeal. Nevertheless, so accurate an observer as Türck has found degeneration of these muscles with that nerve apparently intact, whence he inferred that the innervation in some subjects may be derived from the inferior laryngeal. Paralysis of the thyro-arytenoid muscles is recognized by approximation of the vocal bands posteriorly without longitudinal approximation, so that the glottis is rendered elliptic in phonation when the paralysis is bilateral (Fig. 4964), or bow-shaped when unilateral (Fig. 4965). The paralysis is most frequently limited to the inner portion of this muscle. When the outer portion is paralyzed the image of the vocal band shows want of adduction posteriorly, because the vocal process of the arytenoid cartilage is not thrown inward by the action of the muscle upon its attachment to the muscular process of that cartilage. It is extremely difficult of diagnosis. When both portions are paralyzed, there is a lack of adduction of the vocal bands posteriorly, with a concave curve to the internal border.

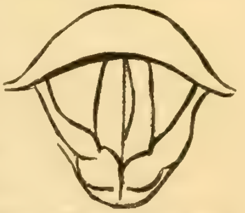
Fig. 4965.—Left-sided Paralysis of Thyro-arytenoid; Phonation.

Paralysis of the arytenoid muscle is shown by gaping in phonation of the posterior or arytenoidal portion of the glottis behind the posterior vocal processes (Fig. 4966); the closure in front being normal, or modified by other conditions as in combined paralysis of the arytenoid and thyro-arytenoid muscles (Fig. 4967). A slight gaping of the arytenoidal portion of the glottis in phonation is observed as a normal condition in many subjects, even in good singers, and this fact must not be lost sight of in making the diagnosis.

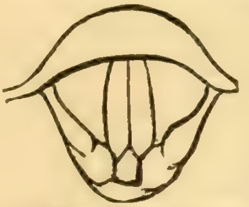
Fig. 4966.—Paralysis of Arytenoid Muscle; Phonation.

In paralyses affecting several muscles, the laryngoscopic picture is more complex than in paralyses of individual muscles; but it can usually be analyzed into combinations of the simpler forms which have been detailed.

The better to comprehend the changes in paralyses, three outlines are appended of the positions of the vocal bands respectively in normal phonation, deep inspi-

[illegible] and [illegible] [illegible] (Figs. [illegible], [illegible], and [illegible]).

Prognosis.—Two factors enter into prognosis: the danger to life, and the prospect of relief from the paralysis. The danger to life is very great in all incurable diseases involving the paths of innervation from the cortex to the nerve-trunk, apart from any direct influence of the paralysis. Two forms of paralysis are very menacing to life, independently of the lesions causing them. These are bilateral paralysis of the posterior crico-arytenoid muscles, and bilateral paralysis of the thyro- and aryteno-epiglottic muscles. In the former, death by suffocation is imminent from inability to breathe. In the latter the fatal issue may be caused by suffocation or by traumatic pneumonitis from escape of food into the air passages. The unilateral paralyses of these muscles are not dangerous. In bilateral paralysis of the abductors of hysterical origin the prognosis is better, though grave for the time being.

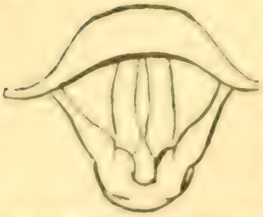

FIG. [illegible].—Bilateral Paralysis of Thyro-arytenoids, with Paralysis of Arytenoid Muscle. (Mackenzie.)

Bilateral paralysis of the entire group of muscles innervated from the recurrent, is far less serious, though sometimes quite grave.

Other paralyses offer no inconvenience to life, although the lesions producing them may be of fatal significance.

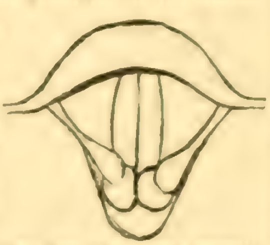

FIG. [illegible].—Phonation (normal).

Relief from paralysis is not to be expected in cases due to serious lesion along the nerve-path, unless the injury has been very slight, and the primary disorder be one susceptible of cure or of amelioration. It is, therefore, in syphilitic diseases that most benefit is to be expected; while reasonable hopes of relief may be entertained in many instances of simple compression of the nerve by enlarged lymphatic glands, by tumors susceptible of removal, and sometimes by foreign bodies. Lesions from traumatic injury cannot be relieved, as a rule.

FIG. [illegible].—Deep Inspiration (normal).

Relief from the paralysis may be justifiably expected in bilateral paralysis of the adductors of functional or hysterical origin: the voice becoming restored by treatment in the vast majority of cases, even when of several years' duration. A few cases resist treatment.

Paralysis of the crico-thyroid muscle is sometimes curable when not due to surgical injury or to degeneration of nerve-fibres.

Isolated paralysis of the thyro-arytenoids is curable in cases due to exposure to unfavorable climatic influences, to laryngitis, and to simple overuse of the voice; but the termination is doubtful in cases due to overuse of the voice during the period of sexual change at puberty.

Isolated paralysis of the arytenoid muscle is usually curable.

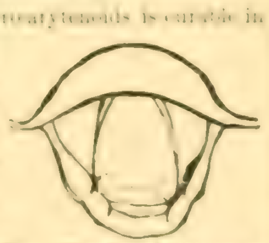

FIG. [illegible].—Bilateral Recurrent Paralysis. Vocal bands motionless, [illegible].

Treatment.—The treatment of laryngeal paralysis varies with the cause and with the effects of the lesion. Except in so far as special conditions may require, treatment is unavailable in paralysis from degenerative disease and injuries of the medulla, of the spinal accessory, and of the pneumogastric; and but little can be expected in cases due to aneurism and malignant morbid growths pressing upon the laryngeal nerves. In other cases treatment must be directed to the pathological lesion, and when this is remediable, as in the removal of a foreign body, enlarged glands, syphilitic lesion, etc., the paralysis may be relieved if the nerve has not suffered permanent injury.

Bilateral paralysis of the abductors requires tracheotomy to relieve the dyspnœa and avert the danger of death by suffocation. Its neglect is criminally hazardous and reprehensible, although the risk is sometimes taken with impunity, especially in hysterical cases.

Bilateral paralysis of the adductors, when of functional or hysterical origin, is often curable by any irritation whatever applied within the larynx, a manœuvre which excites spasm and thereby overcomes the paralysis. The induced electrical current is the most reliable agent, and a spark of static electricity drawn from the larynx externally is often strikingly effective; but even so simple a manipulation as the introduction of the laryngoscopic mirror and an order to say *ah*, will suffice in many instances. These manœuvres may require repetition at intervals of a few days for several days or weeks. Strychnine internally is the best medicinal remedy, and is usually indicated in addition. Constitutional treatment suitable to the systemic condition is to be instituted as a matter of course, whether the remedies be medicinal, hygienic, moral, or psychical.

Paralysis due to toxæmia, to acute infectious disease, to rheumatic influence, to want of exercise of the voice, as occurs in the paralyses of some [illegible], or to too much exercise of the voice, are usually amenable to treatment by electrization, the primary or induced current being applied as directly as possible to the muscles affected or to the nerve-fibres supplying them, at the most accessible or superficial region; and it is probably a matter of indifference in most instances whether the source of electricity be taken from the battery, from the induction coil, or from the magneto-electric machine. Appropriate constitutional treatment is required to avert or restrain relapses. The laryngeal muscles may be subjected to the electric influence through the medium of their motor nerve supply, or through currents passed through some portion of the bodies of the muscles.

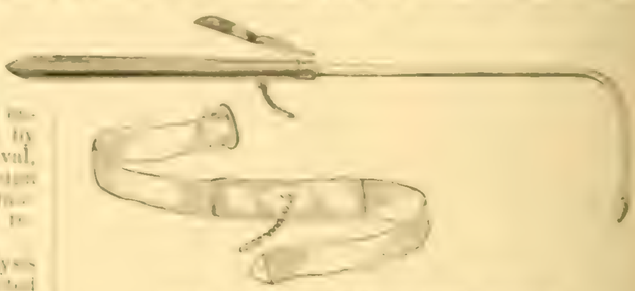

FIG. [illegible].—Mackenzie's Intra-laryngeal Electrode.

The negative electrode should be placed over the part which is to be especially subjected to the current; the other electrode being placed in proximity or at a distance, as may be. When placed at a distance the positive electrode, preferably a disk covered with moistened sponge or flannel, may be held in the hand of the patient, or be applied to the neck. The superior and inferior laryngeal nerves and the crico-thyroid muscle can be influenced from the exterior of the larynx. Direct influence upon the other muscles requires a small curved electrode, with a handle so bent as to facilitate its easy introduction into the larynx. The form adopted by Mackenzie (Fig. [illegible]) is probably the best. It has a spring key controlling the current, which is very easy of manipulation. When it is desired to confine the faradic current as much as possible to one muscle or to a group of muscles a double intra-laryngeal electrode is used, of which one of the best is that of Ziemssen (Fig. 4972). For use externally, small-sized ordinary electrodes suffice. The superior laryngeal nerve can be influenced by placing the electrode on the side of the larynx over the superior horn of the thyroid cartilage, and the inferior laryngeal nerve can be influenced by placing the electrode over the inferior horn between that structure and the sterno-cleido-mastoid muscle (Gerhardt). If allowed to pass through the muscle, the current may influence the pneumogastric disastrously, and produce slowing of the pulse and syncope (Duchenne, Türck, Gerhardt, *et al.*). The crico-thyroid muscle is reached by placing the electrode to the side of the crico-thyroid membrane.

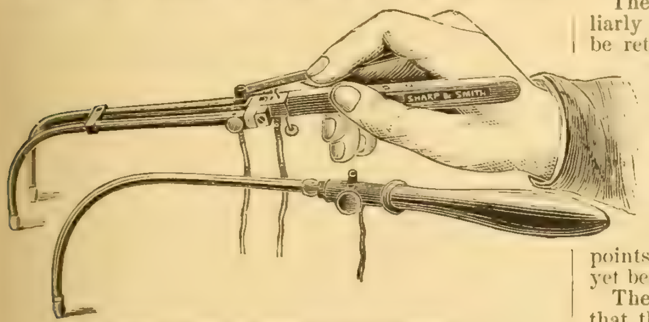

FIG. 4972.—Ziemssen's Double Laryngeal Electrode.

The thyro-arytenoids are best reached by placing the intra-laryngeal electrode upon the corresponding vocal band, and the external electrode over the crico-thyroid membrane. The arytenoid is reached by placing the electrode on the posterior surface of the larynx; the posterior crico-arytenoid, by placing it upon the outer surface of the cricoid cartilage a little to the side of the middle line; the lateral crico-arytenoid at a point considerably further forward than that last mentioned, to the side of the cricoid, and deep down in the pyramidal sinus between cricoid and thyroid cartilages; and the aryteno- and thyro-epiglottici are reached at the sides of the epiglottis. When the electrode is placed upon the posterior or postero-lateral surface of the larynx, that is, between that structure and the tissues of the pharynx and œsophagus, the electrode should be insulated on one side, if it be desired to prevent electrization of the pharynx or œsophagus. Intra-laryngeal electrization should be performed under laryngoscopic inspection, and the strength of the current be regulated according to the effects observed. A current strong enough to move the extensor muscle of the thumb is sufficient in any instance, as a rule; much weaker currents suffice in many. Each application may be continued for ten seconds or a little longer, with one or more interruptions by the use of the key. Two or more repetitions can be made at each sitting, and the sittings may be renewed daily, or at intervals of two or three days, as long as there remains any indication that electricity will continue to be useful.

In paralysis of the thyro- and aryteno-epiglottic muscles from diphtheria, it is often requisite for a considerable period that nourishment should be administered artificially through an œsophageal or a rectal tube, as the case may be. Strychnine is of advantage internally or hypodermically. Little benefit results from topical electrization; for the restoration of tone in the nerve-centre must be awaited, and this does not appear to be at all accelerated by electrization. A spontaneous cure during a course of electrization is often incorrectly accredited to that procedure. *J. Solis Cohen.*

LEPTUS. A parasite of the human skin known popularly as the "harvest mite." Riley considers that there are two species, *l. americanus* and *l. irritans*. Geber, however, considers these as, in all probability, the female and male respectively, and includes both under the designation "*l. autumnalis*."

The mite, which averages 0.3–0.5 mm. in length, and is visible to the naked eye, has a reddish or yellowish-red color. On the head, which is small, compared with the size of the body, is a proboscis, on each side of which are the stylet-formed strong mandibles (Fig. 4973, *m*).

The palpi (*p*), situated a little further back, are peculiarly strong. These are jointed like the limbs, and may be retracted or thrust out; they terminate in a sharp claw. The feet are six in number, three on each side, setting into a socket. Each limb is composed of three parts: a coxa (*c*), a five- to six-jointed tibia (*t*), and a tarsus (*ta*), with two club-shaped terminal bristles. Similar bristles are found along the tibiæ. The abdomen is relatively large, broad, and striated. Thorn-like processes project from the dorsal surface. On the head, on either side of the palpi, are two sharply defined points, the so-called "eyes." Sexual organs have not as yet been discovered upon the leptus.

The negative sexual appearances, as well as the fact that the animal has only six legs, caused Siebold to regard the leptus as a larva of some probably unknown form of mite. Geber, however, suggests, as was before mentioned, that the two "species" or "varieties" are probably male and female.

The *leptus americanus* of Riley is found upon the scalp, in the axillæ, and on other parts of the body, and more frequently upon children than upon adults. It does not completely bury itself in the flesh, but insinuates the anterior portion of the body only beneath the skin, causing a small inflammatory papule.

The *l. irritans* (Riley) is the better known of the two varieties, and is considered by Duhring to correspond to the *l. autumnalis* of foreign writers. It gives rise to considerable annoyance, burying itself in the skin, and causing irritation and inflammation, characterized by the appearance of papules, vesicles, and pustules. It attacks especially the ankles and legs. It is met with in the summer and autumn in corn-fields, upon low bushes, in the grass and weeds along the banks of rivers, and in swampy places. It is said to be very common along the Mississippi River. The little red mite encountered in the swamps and on the low ground of Pennsylvania, New Jersey, and Delaware, especially about blackberry bushes, is in all probability the same species (Duhring).

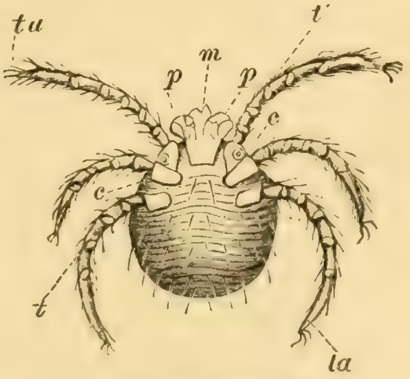

FIG. 4973.—The Harvest Mite.

The disease is best treated with mild parasiticides, as, for example, a weak sulphur ointment employed in the same manner as for scabies.

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Arthur Van Harlingen.

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[1] Dictionnaire Encyclopédique, 2 me ser. t. i., p. 677.

[2] Archives of Medicine, April, 1882.

[3] Thaon: Compte-rendu, Congres International de Laryngologie, p. 47. Milan, 1882.

LYMPHATIC GLANDS, DISEASES OF THE. In entering upon the study of the pathological processes which take place in the lymphatic glands, it is evident that the field of investigation is materially restricted by the fact that these organs constitute only a part, and that a subordinate one, of a system, the more important members of which are the lymphatic vessels. For this reason, nearly all the diseases of the glands are of a secondary or "sympathetic" nature, due to pathological processes in other organs or tissues with which the radicles of the lymphatic vessels, which convey lymph to them, are connected. The only exceptions to this rule, outside of those diseases due to direct traumatism, are lymphadenoma, or Hodgkin's disease, and tuberculous affections of the glands. As both of these are treated of elsewhere in this work, it is not our province to discuss them here.

The lymphatic glands are collections of lymph-follicles, surrounded by connective tissue, scattered in clusters throughout the course of the lymphatic vessels. Their function is now believed to be a double one, viz., to form lymph (or lymphoid) corpuscles, and to act the part of filters or strainers of the lymph.

In the performance of the latter function, the glands of course show that they possess the power to retain and store up within themselves insoluble particles, which, being foreign to the organism, would act as irritants if allowed to gain access to the general circulation. This power is most strikingly shown in cases of the operation technically known as "tattooing," in which the smaller particles of the substance introduced into the skin, usually vermilion, may be found a few hours later in the glands through which the lymph, coming from the injured part, flows, most abundantly in that portion of the gland nearest the afferent vessels. Here it remains permanently, and has been discovered as late as fifty years after the operation.[1]

During the absorption of extravasated blood, red blood corpuscles have been found in the glands outside the blood-vessels, and that at a very early period. Thus Müller[2] found them, within forty minutes after the subcutaneous division of the tibial artery of a dog, in large numbers in the inguinal glands of the side operated upon. As regards the ultimate fate of these corpuscles, it has been found that some of them undergo pigmentary metamorphosis in the lymphoid corpuscles, while the remainder pass unaltered through the lymph channels and find their way back into the blood.

Fat, also, in passing through the lymphatic system, is largely retained by and deposited in the glands, whether it comes from the medullary canal in cases of fracture, from contused fatty tissues, or from exudations undergoing the process of fatty degeneration. In the glands it can readily be recognized collected in large and small drops, within and between the lymphoid corpuscles.

If substances arrested within the glands be intrinsically of an innocuous nature, they produce no structural alteration in them unless they be present in very large quantities. If this be the case, the number of lymphoid corpuscles in the glands decreases, because crowded out by the foreign elements, and because the meshes of the reticulum and the capsules of the glands take on hyperplastic thickening. In consequence of this change, portions of the glands may become transformed into dense fibrillary connective tissue, dotted, in time, with pigment granules. The foreign elements have not been found to penetrate, as a rule, farther into the gland than the outermost cortical layer, at which point in such cases the follicles have been found to be filled with young connective tissue.

While inert substances thus produce no other alteration in the glands than simple hyperplasia of the connective tissue, the case is far different with the invasion of specific agents, e.g., such as are present when the glands become secondarily involved in cases of malignant neoplasms. According to the view now held, the first demonstrable alterations in the glands in such cases consist in dissemination of corpuscular elements which penetrate into the protoplasm and nuclei of the lymphoid cells.[3] The nature of these corpuscular elements can be certainly recognized only in the case of melanotic tumors. They are, according to Gussenbauer, to be regarded as fructifying germs which transmit certain qualities to the constituent elements of the glands, so that the secondary neoplasm takes the type of the original tumor instead of that of the gland tissue.

These corpuscular elements are at first arrested in the lymph channels of the cortex, but later penetrate into the follicles themselves. Early in the disease the microscope demonstrates the presence of small collections of epithelial cells, scattered throughout the cortex of the gland. These proliferate and gradually supplant the normal cells of the gland, until finally the entire organ has undergone a cancerous degeneration, and the new growth begins to invade surrounding tissues. The cells of the reticulum and the endothelium of the vessels also undergo an active hyperplasia, instead of becoming atrophied and degenerating into fat as they would do under the pressure of indifferent foreign elements, and ultimately form the connective-tissue framework of the new growth.

This circumstance, that the tissues of the lymphatic glands undergo proliferation and hyperplasia as a result of their invasion or infection by foreign elements, or in consequence of being irritated and stimulated by the absorption of fluids of a virulent nature, furnishes the type of the changes which these organs experience in the diseases of a simple inflammatory nature which we are now considering. Hyperplasia, induration, fatty degeneration, and sometimes atrophy, are the most common alterations which are met with in inflamed glands.

It is a fact established on the authority of many good observers that every pathological product which has the power to infect the system always excites, when absorbed, a swelling of the glands of that lymphatic territory with which it is brought into contact. This we have on the authority of Bergmann,[4] whose writings have been freely drawn upon in the preparation of this article. This swelling may be acute, subacute, or chronic, and at first always consists in hyperplastic changes within the glands. A striking illustration is furnished by the effects of inoculation with the virus of chancroid, which is invariably followed by enlargement and tenderness of the glands nearest to, and in communication with, the seat of the original lesion. The process is usually an acutely inflammatory one, terminating in suppuration and furnishing a pus capable of exciting suppuration and ulceration when inoculated. In this instance the contagious element, whatever be its nature, penetrates into the gland and there develops its specific action, for the pus from the middle of the gland is just as virulent as that from its periphery.

The hard chancre also is, as is well known, always attended by swelling of the lymphatic glands, in this case of a chronic and indolent type. The first to be affected are those of the groin, when the chancre is seated upon the genital organs, of the elbow and axilla when upon the hand, and of the submaxillary region in cases of chancre of the lip. Later in the disease the swelling involves successively other groups of glands, until none remains unaffected. Swelling and tenderness of the glands nearest the seat of operation also occur after vaccination, and usually terminate in spontaneous recovery.

A sympathetic affection of the glands is common in certain [illegible] diseases, e.g., in erysipelas. In this affection it is often possible to make a diagnosis before the pathognomonic redness of the skin has appeared, from the high fever and the swelling and tenderness of the glands of the affected region. To this tenderness, in fact, the patient generally calls the attention of the physician. In many cases of the disease of a severe type, all the superficial glands of the body become involved.

Swelling of all the lymphatic glands of the body may be said to be characteristic of all constitutional infectious diseases, a phenomenon peculiar to, and an essential part of, them. It is true that this swelling is usually so slight as to escape detection unless a very careful examination be made, which is seldom the case. It can very readily be found to exist in variola, scarlatina, and typhus and typhoid fevers. In scarlet fever a true hyperplasia of the glands, of limited extent, is a constant phenomenon,[5] which may result in suppuration or gangrene. This is especially liable to occur in scrofulous subjects. It is probably the result of septic absorption.

This involvement of the whole lymphatic glandular system is susceptible of two explanations. First, it is possible that the noxious agents may affect the tissues of the glands directly from the blood, as they may do with all the other tissues, as in the well-known instances of typhus and typhoid fevers, in which fatty degeneration of the muscles, heart, liver, and kidneys, is very common. Secondly, it seems not improbable that the swelling may be secondary to the affections of other organs which the disease induces. If the former hypothesis be accepted, the affection of the glands is a specific one, whereas if the latter be regarded as correct, the swelling is purely secondary and sympathetic. In the latter case, in consequence of degenerative processes in the affected organs, a variety of products entirely distinct in nature from the virus which caused the primary disease, may have been carried from the tissues to the glands by way of the absorbent vessels. In cases of mammary cancer the axillary glands may become swollen, either as a result of the immigration into them of specific cancer-cells, or in consequence of the absorption of inflammatory septic products which are never wanting in suppurating growths.

A strong light would be thrown upon this question by positive proof that in cases of swelling of the glands in infectious diseases the micrococci which have, in given instances, been demonstrated to be the causes of the maladies, can be traced into the glands. In malignant pustule, for instance, the cause of which is now known to be the bacillus anthracis, the glands whose lymphatics originate at the point at which the pustule is seated, are always softened, swollen, and of a deep red color, as if infiltrated with blood. The discovery in these glands of the bacillus anthracis would prove that the glandular affection was specific and not sympathetic. In diphtheria, in which the glands are much enlarged in consequence of cellular hyperplasia, while the periglandular cellular tissue is œdematous and often the seat of capillary hæmorrhages, micrococci *have* been found in the glands by numerous observers, especially by Oertel[6] and Barth.[7] No specific micrococcus has, however, been as yet shown to be the cause of diphtheria.

Some help toward the solution of this question is furnished by the experiments of Gaffky.[8] This author succeeded in producing in mice and rabbits, by the inoculation of a micro-organism cultivated outside the body, a disease which usually terminated fatally, within twenty-four hours. The autopsy always showed marked enlargement of the spleen and lymphatic glands, without discoverable changes in other organs. The microscope, however, detected in the blood in all parts of the body a morphologically very distinct form of bacterium, which was recognized as occupying a position midway between a micrococcus and a bacillus. Examination of the swollen glands showed these bacteria inside their blood-vessels, but not in the lymph-channels. Similar conditions were found in the glands by Koch, in his experiments in the production of septicæmia in mice by the inoculation of another form of bacterium. Also in animals which had died of the so-called "malignant œdema" Bergmann found the glands invariably enlarged, and dotted here and there with extravasated blood. He regards it as probable that in these cases the micro-organisms were carried to the glands by the lymphatics and not by the blood-vessels.

Another fact which goes to support the belief that the swelling of the glands in infectious diseases is due to the presence within them of the micro-organisms peculiar to the affection is this, that when fluids rich in the bacilli of decomposition are injected into the abdominal cavities of rabbits, these structures can be found in the reticular lymph spaces of the rapidly swelling glands even before they can be discovered in the blood. This fact was demonstrated by Fehleisen and Soubbotine.[10]

Whichever view of this question is adopted, and it must be admitted that in the present state of knowledge it is a difficult one to answer positively, the fact is at all events established that every artificial disease produced by the inoculation of bacteria, regardless of the location of the parasite, whether in the blood or in the connective tissue, is attended with an acute swelling of the lymphatic glands.

Not only is the swelling of all the glands of the body the result usually of an infection of the organism, but also that of a single group of glands is often, in a certain sense, of infectious origin. It has long been taught, and is still believed, that every swelling of a gland is the result of an inflammation at the point of origin of its afferent vessels. This inflammation, it may be confidently stated, is in all instances of an infectious nature, using the adjective "infectious" in the broader sense which it now conveys. Formerly the soft chancre, the "chancroid," was regarded as the type of a local affection which was capable of causing swelling and suppuration of the communicating glands. The hypothesis of the penetration of some infectious material from the infiltration upon the genitals into the glands was a natural one, since there could be no doubt but that the primary disease was transmissible and infectious. But a careful examination of other somewhat similar cases showed that in all those affections of the skin and mucous membranes which are usually attended with swelling of the glands there is, as a common feature, a something which is the first and most important requisite to the penetration into the body of foreign organisms, viz., a solution of continuity in blood-vessels or lymph spaces. In all diseases of this nature there occurs a removal of the protection which the epidermic and epithelial coverings furnish to the underlying tissues, a barrier which must first be overcome before we can inoculate any disease. We know that the inflammation of the glands is not dependent upon the nature or extent of the injury, but solely upon the question whether or not the skin or mucous membrane is broken or lacerated, and whether or not infecting germs come into contact with the lesion. The results of modern antiseptic surgery go to prove every day that if wounds are kept in an aseptic condition no inflammation (with its glandular swelling) will occur. Since also open wounds, in comparison with subcutaneous injuries, are especially prone to take on suppurative action, the conclusion seems justified that certain noxious agents present in the former (and necessarily absent in the latter) are the direct causes of suppuration, and as it is the teaching of every-day observation that suppurative inflammations are, as a rule, attended by glandular swelling, we are warranted in stating that lymphadenitis, both acute and chronic, is a disease which is directly caused by the penetration into the lymph channels and glands of infectious materials coming from without the body.

Suppurative inflammations which give rise to glandular swellings may conveniently be divided into two classes, superficial and deep. Of the former are inflammations of the skin and catarrhal affections of mucous membranes; of the latter, subcutaneous phlegmonous inflammations, local and diffuse, furuncles, onychias, burns and frost-bites, and all gangrenous and deep ulcerative affections. Catarrhs of the gastro-intestinal and pulmonary mucous membranes are the most common causes of affections of the former class. Here the lymph follicles seated in the mucous membranes are first affected, and later the glands connected with them. Thus a very close relationship is noticeable between diseases of the bronchial tubes and their lymphatic glands.[10] The affections of the glands here vary, with the duration and intensity of the bronchial affection, from simple hyperæmia or hyperplasia to chronic inflammation, with pigmentation, cheesy degeneration, or calcification. If they have acquired such a size as to compress the larger bronchi, or nerve or arterial trunks, they may even produce bronchial stenosis with its usual results.

In such cases the most plausible explanation of the adenitis is that the delicacy of the inflamed epithelial stratum affords no obstacle to the passage to the deeper layers of the membrane of the noxious organisms always present in the inspired air, or in the contents of the intestinal canal, as the case may be.

Similar conditions prevail in the superficial affections of the skin and in certain forms of eczema, which disease has been regarded by some as the analogue of a catarrh of a mucous membrane. In these the resisting or protective power of the epithelial layer is much lessened or entirely overcome, and in consequence of this the integrity of the rete Malpighii is impaired, and the passage of irritating organisms into the subcutaneous connective tissue permitted. For this reason there are but few cases of chronic eczema which are free from symptomatic affections of glands. In fact, swelling of these organs is a necessary attendant upon all itching, excoriating, and crusty diseases of the skin, including the prurigo of Hebra, scabies, and phthiriasis capitis. In all these instances the cause of the swelling is doubtless the same, viz., the penetration into the subcutaneous tissue of noxious agents deposited upon the surface, access being gained through the lesions of the skin produced by the fingers of the patient; and their transportation into the lymphatic vessels and thence into the glands.

Having reached these organs the foreign organisms act as irritants, causing a swelling of the glands which stands in an exact relationship with the specificity and intensity of the original local process. If the original lesion be, for instance, a soft chancre, an acute suppurative adenitis is developed which may become diphtheritic or gangrenous if the chancroid itself take on these changes. If connected with more indolent or less virulent lesions, the affection of the glands is also sluggish and indolent.

In its development, also, the swelling of the glands keeps pace with that of the primary disease. This can often be observed during the course of an erysipelas or of an impetiginous eczema of the scalp, or of an acute stomatitis. As the original disease grows worse the glands become more swollen and painful, and decrease in size and become less tender as the patient's condition improves.

In the case of a circumscribed affection of the skin, or of a mucous membrane, the swelling is for a time confined to a few glands, but later in the course of the disease the entire group in connection with the affected region becomes involved. If recovery do not take place the swelling invades the next group of glands in the direction of the lymph current. Matters remain in such a state, however, that the first group is always most severely affected, the swelling becoming gradually less the further from the original seat of disease the glands are situated. (This fact furnishes an additional illustration of the retentive power of the glands already spoken of.)

While the penetration into the glands of noxious germs or fluids from without, must with our present knowledge be regarded as the main cause of their swelling in the immense majority of cases, it may also be said to be the sole cause of their suppuration. Exceptions to this statement may, perhaps, be furnished by those cases in which glands suppurate in consequence of traumatism directly applied. Thus cases are not very uncommon in which glandular abscesses are met with in the axilla in consequence of the pressure of the head of a crutch. As regards the first part of the statement just made concerning the cause of the swelling of glands, it cannot be doubted that the practitioner meets now and then countless cases of acutely enlarged glands in children, in which the most careful investigation fails to detect any possible cause. Such swellings usually occur in the glands underneath the angles of the jaw, and are neither diphtheritic, nor are they the result of catarrh of the ear or throat, nor of scrofulous origin. Fortunately the swelling rarely suppurates, so that their importance is of a scientific rather than of a therapeutic nature.

The statement that the presence of noxious germs from without must be regarded as the sole cause of suppuration of glands, is borne out by the study of cases in which hyperplasia takes place without it being possible for such agents to have penetrated into the glands. In [illegible] blood-clots, e.g., the nearest glands are sometimes found to be swollen and tender. Here it seems not unlikely that certain ferments have developed in the clot which have been carried into the glands, and have stimulated them unduly.

It has been asserted that long-continued muscular exertion may cause swelling of glands, and that those of the axilla are generally enlarged in laboring men. If this be true, it is readily explained by the fact that men of this class are very often the subjects of slight lesions on the hands, which may permit access to the lymphatic system of external irritants. It is also not improbable that the excessive use to which such persons put their muscles leads to a constant increase in the quantity of lymph passing through the glands, a lymph richer than usual in the products of tissue metamorphosis, and hence capable of stimulating the glands to a physiological hypertrophy similar to that which the muscles undergo.

The first noticeable change in a diseased gland is an increase in size. In infants it is usually impossible to discover the glands by palpation or any other means. They first become recognizable at the age of from five to six years. At this time of life they may be felt as small isolated nodules of an oval shape, not sensitive to touch, and capable of being displaced under the skin. Their outlines are distinct, their consistence firm and elastic, and their surfaces smooth. They are always arranged in groups made up of glands varying greatly in size, from that of a pin-head to that of a bean, and are disposed in two sets, superficial and deep. The former are most numerous in the folds of the flexures of the large joints, and around the great vessels of the neck and limbs. The deep-seated are most abundant around the vessels coming from the large glandular viscera. At the period of second dentition some of the glands in the submaxillary region become appreciable to the touch, and at puberty those in the inguinal region. They usually become more distinct as the person grows older, for the reason that they increase in size with the rest of the body, and also because they are often subjected to slight disturbances of nutrition from the injuries and diseases to which they are liable. The enlargement of the glands along the lower edge of the lower jaw, which is so common at the period of second dentition, is due to the swelling which they undergo as the result of caries of the first teeth, inflammation of the gums, alveolar periostitis or stomatitis, affections which are so common at this period. Traces of the (usually temporary) swelling remain in the shape of slight permanent enlargement and induration. This fact explains why it is usually easy to make out the location of these glands in the majority of adults.

The discovery of enlargement of lymphatic glands should always lead to the suspicion of the existence of some pathological process in the region from which their afferent vessels originate. Thus enlargement of the glands under the angles of the jaw should lead the practitioner to suspect the presence of nasal or pharyngeal diphtheria. In some cases the presence of an enlarged and indurated gland in the median line of the neck, just above the thyroid isthmus, has furnished the first sign of the existence of a malignant neoplasm in the interior of the larynx. It must not be forgotten that in many epidemics of mumps the inflammation and swelling are confined exclusively to the subauricular and submaxillary lymphatic glands, the parotids not participating in the trouble to any appreciable extent; and yet that the disease is undoubtedly mumps is shown by its contagiousness and by the occasional occurrence of a typical parotitis during the course of the epidemic. Such an epidemic has been described by Penzoldt and one has recently been watched by the present writer.

In acute lymphadenitis, the most important alteration in the glands is an acute hyperplasia. This affection has been made the subject of careful study by Yeo and Lassar[17]. The latter excited acute inflammation in the glands of a dog by injecting oil of turpentine into them, and invariably found that only a portion of the parenchyma was affected, the rest remaining normal. The glands were soft, moist, and succulent on section, and of a much redder color than natural, due to active hyperæmia. This had also produced numerous small extravasations of blood. Microscopical examination showed marked swelling of the follicles, those of the cortex seeming to be filled full of lymphoid corpuscles with indistinct contours. In the dilated lymph-channels, besides normal lymph-corpuscles, many larger ones of irregularly oval shape, with several nuclei, could be seen. The trabeculæ of the gland and the finest reticular tissue showed no alteration. If the inflammation progressed these changes became more marked, and the vessels greatly dilated and distended to bursting with blood-corpuscles. The large multi-nucleated cells were probably lymphoid cells undergoing transformation into pus-corpuscles. Proliferative changes were also recognizable in the endothelia of the smaller blood-vessels.

The swelling of the glands in acute inflammation is therefore due to a numerical increase in the number of the lymphoid cells, with dilatation of the capillaries and retention of lymph. That the last is a factor in the causation of the swelling is shown by an observation of Lassar, who found an enormous increase in the quantity of lymph flowing from the vessels coming from the inflamed glands, whereas, under normal conditions, but one small drop flowed at intervals of about ten minutes. The amount could be greatly increased by passive motions of the limb to which the inflamed gland belonged.

Whether or not, in cases of septic adenitis, micro-organisms are present in sufficient numbers to materially contribute to the production of the swelling, must at present be left undecided, since careful microscopical investigations of this subject have not yet been made. In diphtheria, however, as has already been stated, numerous colonies of micrococci have been found in the glands by a number of authors.

According to the doctrine of the essential nature of inflammation now generally taught, the source of the lymphoid cells, whose increase in number and size is so marked a feature of the swelling of glands, is the blood capillaries. Although this may be true to a certain extent, it also seems probable that a part of them, at least, may originate from the reticulum of the gland as the result of proliferation. This is believed by Billroth, Yeo, Hansen, and Ranvier. Still another possible source of the new cells is from pre-existing lymphoid cells. Hyperplasia of the connective tissue of the trabeculæ is at all events the invariable result of inflammation of the glands.

Pus first shows itself in the gland in the form of distinct, scattered collections in different portions of the parenchyma of the organ. On section of a suppurating gland, yellow spots of the size of a pin-head are visible, containing thick creamy pus, and bearing a marked resemblance to follicular abscesses of the intestinal wall. Later these increase in size, spread and become confluent, the entire gland ultimately becoming transformed into an abscess, with shreds of tissue traversing its cavity, the remains of the parenchyma.

The surrounding connective tissue has by this time become the seat of a phlegmon, a "cellulitis," of greater or lesser extent. This participation in the inflammatory process of the periglandular tissue is doubtless due to the presence in the vasa afferentia of the affected gland of the materies morbi which caused the original trouble. The great number of these vessels is perhaps best seen in the mesentery in some fatal cases of typhoid fever. In many such these vessels are found to be enormously distended with large and small cells within and between which may be found extensive masses of the short, thick bacilli of Eberth.

These complicating inflammations of connective tissue are modified by the nature and intensity of the original irritation and also by the anatomical peculiarities of the planes in which they are developed. For the latter reason acute suppurative inflammations of the glands sometimes lead to very serious and even fatal results, as, *e.g.*, when suppuration sets in underneath the deep fascia of the neck, the pus burrowing downward and breaking into the mediastinum.

The extravascular accumulation and growth of cells in the parenchyma of the gland may be so great that the vessels are not only partially but wholly obstructed. In consequence of this the substance of the gland may become in spots pale from anæmia, and even gangrenous. This condition is often encountered in typhoid-fever cases, and may result in cheesy or calcareous degeneration of the necrosed mass, or in its removal by absorption, as is fortunately generally the case. Similar changes may take place in the glands beneath the angles of the jaw in diphtheria.

If the inflammation of the gland is destined to terminate in resolution, as is usually the case, the accumulation of lymphoid corpuscles is arrested at an early stage, and the greater part of them is carried back into the circulation. Another portion undergoes fatty and granular degeneration, and is reabsorbed. But as the progress of an acute lymphadenitis is always associated with increased growth of the fixed connective-tissue cells of the reticulum, an absolute restitution to the normal condition does not occur, and a permanent alteration in the framework of the gland always remains. This consists in a thickening of the connective tissue of the septa and reticulum, leading to induration and chronic enlargement of the gland. At a very late period the gland may undergo partial atrophy, but the induration remains through life.

In all acute infectious diseases it is the rule for the swelling of the glands to terminate in resolution. Exceptions to this are, however, quite common, especially in scrofulous subjects. The result of the swelling depends, in fact, to a large extent upon the nature of the cause of the original disease. Thus the bubo attendant upon chancroid ordinarily suppurates, whereas glands enlarged from constitutional syphilis never do so. It may be said that the tendency to suppuration is most marked in glands inflamed as a result of localized affections.

Etiology.—In the axillary region acute lymphadenitis may develop either with or without a preceding lymphangitis, or, at least, without discoverable evidence of it. It is much more common in adults than in children, because the hands and fingers of the former are much more exposed to those injuries in whose train the glandular affection is apt to develop. Children do not have the callous spots on the hands, collections of pus under which are frequently the cause of adenitis. Direct traumatism is a not infrequent cause of axillary adenitis, as the pressure of the head of a crutch. In children onychias, the so-called "run-rounds," often excite glandular inflammations in the axilla, and deep eczematous fissures or ulcers over chilblains may cause the same trouble in the axillæ or groins of adults. Itching pustular eruptions, *e.g.*, scabies, may cause lymphangitis, and subsequent adenitis. Bergmann once saw an acute suppurative inflammation of an axillary gland follow an acute suppurative mastitis in a child.

Lymphangitis from dermatitis is very common in those who walk a great deal in improperly constructed shoes, and is often attended with a rapid swelling of the inguinal glands, which, however, but rarely suppurate. Injuries to the hands or fingers of a special kind, such as those from insect-bites, contact with the poison of cadavers, or certain infectious diseases of wounds, often lead to rapid suppuration of the axillary glands. In all cases of this nature this is preceded by lymphangitis, characterized by the development of red lines running up the arm, and attended by great constitutional disturbance. The involvement of the glands sometimes occurs with surprising rapidity. Thus Hunter relates that a patient once called his attention to the fact that he felt pain in the axilla five minutes after his (the patient's) finger was accidentally punctured with a needle. On examination, Hunter was able to recognize a distinct enlargement of the glands in that situation.

The knowledge that the glands act as filters of the lymph flowing through them long ago gave rise to the belief that the swelling of these organs was a salutary one, protecting the system against infection. According to the same belief the suppuration was also advantageous, as the poisonous material which the gland stored up was supposed to be discharged with the pus. The fact that constitutional disturbance and pain always rapidly decline after the breaking through the skin or the artificial opening of a glandular abscess, and also that constitutional infection does not occur after suppurating buboes of venereal origin, also seem to lend weight to this view. It is, however, doubtless incorrect. It is much more probable that the character of the infecting micro-organism alone determines whether or not its action remains restricted to the lymphatic system and consecutive tissues, or passes into the blood and infects the whole organism. If the inflammatory bacteria are capable of vegetating in the tissues as well as in the blood, as in malignant pustule and diphtheria, the glandular affection does not afford the slightest defence against general infection. In chancroid, on the other hand, the poisoning material limits its action to the local destruction of tissue at the point of inoculation and the glands, but cannot continue to live and reproduce itself in the blood, and for this reason alone systemic infection does not take place. The same is true of lymphadenitis which follows most suppurative processes on the fingers. The constitutional disturbance which attends them owes its origin to the blood-changes produced by the taking up of inflammatory material from the focus of disease.

Although the glandular swelling may develop early in the course of the lymphangitis, its further course toward suppuration is usually slow. Five or more days usually elapse during which the gland grows steadily larger and more tender, but may still be displaced under the skin. If the swelling do not subside the gland becomes still more sensitive and fused together with the overlying skin and adjacent similarly affected glands, if such there be, and its contours become lost in the inflamed periglandular connective tissue. The entire groin or axilla, as the case may be, seems filled with a large, doughy mass. The skin is tense and glistening, and finally becomes oedematous. Careful examination shows harder, alternating with softer spots, and finally fluctuation is detected. The spot at which this is observed is usually surrounded by a dense wall of infiltrated tissue, and the skin over it soon becomes reddened and thinned, and finally bursts. The pus escapes and leaves an ulcerous cavity with undermined and overhanging edges. While quick healing is the rule if the opening be free, it is usually slow when the case is left to the unaided powers of nature.

The same glandular suppuration may also take place without the intermediary of a lymphangitis. Here also the swelling occurs early and suppuration is delayed. For this reason the original cause of the trouble, the pustule, or fissure of the skin, may long since have healed and been forgotten before attention is drawn to the glandular inflammation. These are the cases which are spoken of as illustrations of acute idiopathic suppuration of lymphatic glands, an affection which, probably, never occurs.

In children acute lymphadenitis is much more common in the neck than in the axilla. A connective lymphangitis can here almost never be demonstrated. Acute inflammation of the submaxillary glands follows as a rule diseases of the lips and mouth, especially of the gums and teeth. It is analogous in all respects to the chronic swellings of the same glands, so that it is often difficult to decide why an inflammation of these glands should be acute rather than subacute or chronic, as it usually is. It is doubtless dependent upon the intensity of the original inflammation and its cause.

Acute inflammation of the submental glands is ordinarily due to fissures of the angles of the mouth so common in scrofulous children. These fissures become inflamed and may induce suppuration of the gland under the anterior belly of the digastric muscle. Ulcers formed during dentition or pertussis may also give rise to the disease. The deep location of the gland renders the swelling impalpable, so that a correct diagnosis is often difficult.

A simple nasal or oral catarrh may also be the exciting cause of a gradual swelling of the neighboring glands, usually terminating in resolution, however. Many a case regarded as scrofulous in origin from the presence of a [illegible] chronic swellings of the lymphatic glands may be readily interpreted by the discovery of a chronic nasal catarrh or eczema of the buccal mucous membrane.

Chronic lymphadenitis, being usually of a syphilitic or scrofulous nature, constitutes a phenomenon of these diseases and shall not therefore engage our attention.

Treatment.—Acute lymphadenitis developing in the course of diphtheria, scarlatina, chancroid, or any of the essential fevers is a part of that particular disease, and its treatment is described under the particular headings in other portions of this work and need not detain us here.

When it is secondary to diseases other than those named above, the situation and nature of the original trouble should, of course, be determined, and the appropriate treatment instituted. If a patient present himself stating that he has a lump in his groin which causes pain, the physician should at once suspect herpes, chancroid, or some injury of the foot, either an infected wound or bunion, or an ingrowing toe-nail. Thorough cleansing of the latter, with the proper use of antiseptics, will usually at once arrest the inflammation of the gland in the groin, which will rarely require any other treatment than rest in bed and the application of tincture of iodine, or of a warm poultice. Fortunately sympathetic inguinal glands rarely suppurate, this result occurring only in badly nourished or scrofulous subjects. In such persons, of course, iron, cod-liver oil, and other appropriate tonics are indicated.

Children are often brought to physicians for treatment of enlarged and painful glands in the back of the neck, on either side of the occipital protuberance. Such swellings are always due to the presence of lice in the hair, or, rather, to the artificial eczema which they excite, and the glandular inflammation requires no other treatment than the destruction of the parasites. Suppuration almost never occurs in such cases.

When there is marked constitutional disturbance in acute glandular inflammation, absolute rest in bed should be prescribed, with the administration of a brisk cathartic and sufficient opium to relieve pain. In robust subjects the local treatment should be at first vigorously antiphlogistic, viz., the application of two or three leeches around, not over, the gland, rubbing the skin over it with a moistened stick of silver nitrate, the application of the tincture of iodine, or the continuous use of the ice-bag. In some mild cases of acute swelling of the glands under the angles of the jaw in children, the writer has seen marked subsidence of the tenderness and swelling after the application of a one to three solution of tincture of lobelia in water, on a compress covered with oiled-silk, a therapeutic application originally obtained from extra-professional sources.

If suppuration be inevitable, antiphlogistic treatment should of course be abandoned, and hot applications, either water as hot as can be borne, or poultices, should be resorted to. Here, of course, free incisions are indicated, even before fluctuation can be detected, that a free discharge may be given to all pus and tissue debris. In some cases of suppuration of glands underneath the sterno-cleido-mastoid muscles, with alarming [illegible], numerous incisions through the deep fascia must be made in order to release the compressed tissues and to obviate burrowing of pus, which may become very dangerous in this situation.

W. T. Alexander.

[1] Ziegler: General Pathology.

[2] [illegible]: Untersuchungen über die Vorgänge bei [illegible] der Lymphdrüsen [illegible]. [illegible], 18[illegible].

[3] [illegible]

[4] [illegible]: Erkrankungen der Lymphdrüsen, in Gerhardt's Handbuch der Kinderkrankheiten, 18[illegible].

[5] [illegible]: Acute [illegible], in Ziemssen's Cyclopaedia of the Practice of Medicine.

[6] [illegible]: Acute [illegible], in Ziemssen's Cyclopaedia of the Practice of Medicine.

[7] [illegible]: Beiträge zur Kenntniss der Lymphdrüsen. Centralblatt für die med. Wissenschaften, 18[illegible].

[8] [illegible]

[9] [illegible]

[10] [illegible]: Acute [illegible], in Ziemssen's Cyclopaedia.

[11] [illegible]

[12] [illegible]

[13] [illegible]

LYMPHATIC SYSTEM. Synonyms: Absorbent system; Latin, Systema lymphatica; French, Système lymphatique; Italian, Sistema linfatico; German, Lymphsystem oder Saugadersystem. The lymphatic or lymph vascular system consists of the vessels and spaces containing lymph or chyle (colorless or white blood), and of the lymphatic or conglobate glands situated in the course of the vessels, and through which the lymph must percolate something as if passing through a sponge. This system is an appendage of the blood vascular system, its two terminal trunks, the thoracic duct, and the right common lymphatic trunk, ending in the great veins at the base of the neck.

A tolerably correct pictorial idea of the entire vascular system may be formed by considering the blood vascular part as made up of a great tree, the heart forming a short trunk and the arteries, veins, and capillaries, the branches; but there is present the untree-like character of the direct union of the terminal twigs of the arteries and veins, that is, the venous and arterial capillaries are continuous. The lymphatic system may then be represented by two vines of unequal size, but which together follow all the blood-vessels to their ultimate ramifications, and in many places even send minute twigs beyond them. The analogy with a vine is further borne out by the lymphatic vessels, as they remain of a more uniform diameter than the blood-vessels; and finally the terminal twigs, like those of a real vine, end freely or blindly, often in slight expansions like leaves, thus forming a marked contrast with the terminal twigs of arteries and veins, which cannot be properly said to terminate at all. In a word, the blood vascular system forms a complete circle or circuit in itself, while the lymph vascular system joins the blood vascular system at its central or trunk end, but ends blindly at the periphery.

Historical.—Perhaps it is not to be wondered at that the lymphatic system should not have been discovered and investigated before the circulation of the blood and the general relations of the blood vascular system had been investigated and understood, and yet, from the prominence of the lymphatic glands they were seen by Hippocrates; but, having no notion of their true relations, he classed them with the other glandular structures of the body; so, too, there is strong reason for believing that the lacteals were seen in animals by the two famous Alexandrian physicians, Erasistratus and Herophilus; but their significance was not comprehended. About the middle of the sixteenth century (1564), Eustachius found the thoracic duct in the horse, and traced it, both to its beginning in the abdomen, where he became bewildered, and to its termination in the great veins in the neck. He did not profess to understand the significance of this vessel, but named it, from its color and position, *vena alba thoracis*.

It was not until 1622, when Asellius saw the lacteals in a dog, that the real significance of these vessels was appreciated. The whole scientific world was about this time aroused by the epoch-making discovery of Harvey on the circulation of the blood, and everything like a vessel was scrutinized with inquiring eyes. The story of Asellius in connection with the discovery and comprehension of the significance of the lacteals will never lose its interest as long as the human mind is striving to comprehend the universe, either in its details or in the ensemble. Having opened the abdomen of a living dog, to show to some friends the arrangement of the nerves and the working of the diaphragm, Asellius saw in the mesentery some white cords in addition to the nerves and vessels with which he was familiar, and upon cutting one of them and seeing a white liquid exude, he immediately recognized that they were a new kind of vessel. Most fortunately for him and for science, the dog, killed on the following day to find out still more about these curious white veins, showed none of them. Fortunately, because it led Asellius to consider the conditions under which they appeared in the first dog, and wherein the conditions differed in the second. With the sure comprehension of a scientific mind, he saw that the only essential difference lay in the presence of partly digested food in the first case, and in the absence of food in the second. When this condition was realized in a third dog, the lacteal vessels reappeared, and the relation between the products of digestion and these vessels was fully established for the dog.

Not content with the experiments on the dog, Asellius examined many other animals, showing in every case that there was a constant relation between digestion and the presence of the white fluid in the lacteal vessels. Owing to the powerful influence of the prevailing opinion that all matter must first go to the liver to be assimilated, Asellius supposed that the newly found lacteals extended to the liver. It is difficult to comprehend how a mere hypothesis could blind the eyes of so skilled an anatomist, but so it was, and the belief that the lacteals passed to the liver prevailed for nearly twenty-five years, till about 1650. It may be said in passing, that when the facts concerning these new vessels were presented to Harvey, he did not welcome the newly acquired knowledge. Doubtless the weight of years had quenched the enthusiasm of investigation, and he may have been troubled lest these newly discovered vessels might in some way prove a stumbling-block to his simple and easily comprehended explanation of the blood vascular system.

About 1650, the great facts concerning the lymphatic system, as they are understood at the present day, were discovered by four men in different quarters of Europe. In France, Pecquet showed that the *venæ aquosæ hepatici*, or lymphatic vessels connected with the liver, were not the continuation of the lacteals to the liver, but were vessels extending either to the lacteals, or with them into a common reservoir into which both opened, and that the reservoir was continued as a somewhat smaller vessel (the thoracic duct) through the thorax, to terminate in the great veins in the neck. The same facts were observed by Rudbeck, in Sweden, at about the same time, and completely overthrew the notion that all absorbed food must first pass to the liver for assimilation before entering the blood; for here was *apparently* the only path of the absorbed food, and it terminated directly in the great veins on their way to the heart.

At about this date, Bartholin in Denmark, Jolyff in England, and Rudbeck in Sweden, discovered the general lymphatics of the body. They also showed that these lymphatics (*Vasa lymphatica* of Bartholin, *Vasa aquosa* of Rudbeck), or serous vessels either united with the lacteals in the *chylocyst* or joined the thoracic duct, and consequently the lymph and chyle or lacteal fluid unite, and together flow into the great veins. In other words, they showed that the lacteals form only a special part of a great system distributed throughout the entire body.

Not much was added to the knowledge of the lymphatic system for nearly one hundred years after the main facts were established, and naturally, in those early times, with undeveloped methods and superstition both as impediments, knowledge was only general and obtained principally by investigating the lower animals. And yet, in 1628, a criminal was properly fed before execution, and the lacteals demonstrated in the mesentery after death, thus showing conclusively that the absorbed food in man takes the same course as in animals.

Between 1760 and 1787 there was a renewed activity in investigating the lymphatic system. In England the Hunters, Hewson, and Cruikshank, not only investigated the human lymphatics, but pushed their investigations to all forms of vertebrates, and they were found abundantly in all forms. The Monros, in Scotland, were also very active. In Italy the great anatomist, Mascagni, was preparing his magnificent work on the human lymphatics, a work which is still a standard; and reduced copies of his splendid folio plates are still to be found in every extensive account of this system.

As in all departments of human activity, the crowning discoveries in the lymphatic system are due to the work of an almost untold number of men; and yet a few present the principal and salient features so unincumbered with useless, distracting, or foreign details, that they are, for the majority of which the true discoverers. They make the obscure discoverer a part of the knowledge of the past. So in the many historical [illegible] many names have been omitted and undue prominence may have been given to others. Leaving these defects it is hoped that is represented fairly well the progress from vague and erroneous to correct knowledge of this system.

Since the work named above, something noteworthy has appeared almost every decade, but it has been mostly toward the elucidation of special details of function, origin, development, or structure, rather than an investigation of the whole field. The work of Sappey forms an exception to this general statement. His investigations have extended over more than forty years and with a vast care and all the refinement of modern methods, he has not only done much on the general subject both in human and comparative anatomy, but many of the difficult points have been elucidated by him. His atlas is probably, without qualification, the most important monograph that has appeared since Mascagni's.

GENERAL STRUCTURE IN MAN AND ANIMALS.—Considered as a whole, the lymphatic system consists of minute and larger vessels, of distinctly walled capillaries and larger trunks. Lymphoid or adenoid tissue seems also to be an integral part, and in man and the higher forms this adenoid tissue is, in part, aggregated into special masses, the lymphatic glands, situated in the course of the vessels and forming a sort of sponge-work through which the lymph must percolate on its course to join the blood-vessels.

Like the blood-vessels, the lymphatics may be divided into groups according to their position, as (a) subcutaneous, subserous, or superficial, and (b) subintermuscular, submucous, or deep; and as visceral, those belonging to the heart, lungs, urinary and generative organs, and the alimentary canal. Part of these, e.g., those from the small intestine, are called lacteals or chyle-vessels. All of the larger vessels possess more numerous valves than do the veins.

In distribution, the lymphatics follow mostly the course of the blood-vessels, but this does not apply to the subcutaneous lymphatics, as will be seen by comparing Figs. [illegible] and [illegible], with figures showing subcutaneous veins. Furthermore, in many situations lymph-vessels or lymph-canals and spaces extend beyond the blood-vessels and more intimately envelop the tissue elements.

The lymphatic capillary network, although agreeing in general appearance to a blood capillary network, is composed of larger vessels and its mesh is coarser. With the larger vessels the anastomoses are more frequent, but differ in character from the anastomoses of blood-vessels inasmuch as the parallel vessels divide equally or unequally and unite at a very acute angle, making a long narrow meshed network (Fig. 4979), and nowhere is found the great disparity in the size of the vessels as is found with the great arterial and venous trunks. Even the terminal lymphatic trunks are minute as compared with the vessels which they supply. The entire lymphatic system is supposed to have a capacity one half as great as the venous, and perhaps more, but no exact determination can be made on account of the structural peculiarities of the lymphatics, and the immense number of valves. In man and the higher forms, all lymph is supposed to traverse one or more lymphatic glands before joining the common lymphatic trunks.

In the higher mammals the general arrangement and distribution of the lymphatics is as in man. So far as has been investigated, however, the lymphatic vessels are fewer in number; this is markedly the case with the cutaneous and subcutaneous vessels. The lymphatic glands, although abundant in the horse and ox, are less numerous in most forms. Groups of glands in man are often represented by a single one or are wholly absent. Although fewer [illegible] a vessel finally of many joins the great trunk without first traversing one or more glands (Figs. 4975, 4980, and 4981). In the lower mammals there is a strong tendency to symmetry in the lymphatic system, the right and left terminal trunks being more nearly equal in size and in the area from which the vessels come. This tendency is also marked in the horse, and especially so in the rabbit; it is frequently observed in the cat, also occasionally in man. The crossing of considerable trunks from one side to the other is more marked in the lower mammals than in the higher, but even in man considerable trunks not infrequently cross from one side to the other (Figs. 4975 and 4976, 4977), and in all the forms there is the closest possible relation between the two sides through the lymphatic plexuses, that is, networks formed by groups of lymphatic glands and their connecting lymphatic vessels. While it is not uncommon to speak of a network of lymphatic vessels as a plexus, the term is coming to be restricted rather to a lymphatic network in which the glands form the nodal points of the mesh (see Fig. 4974).

Of the animals below the mammalia, the birds possess few lymphatic glands, and those are restricted to the neck, or in a few forms to the neck and axilla. A cutaneous and subcutaneous lymph network has not been demonstrated in the birds. Those that have been shown, it is supposed, correspond with the costal and visceral lymphatics of mammals. The two trunks opening into the veins of the neck are symmetrical, that is, equal right and left trunks. There are also two openings for the lymphatics in the pelvic veins, and lymph hearts are found in this region, but they have muscular walls in only few forms (ostrich, cassowary, stork, and some gulls). Lymph hearts are never present in man and the other mammals, although, in addition to the birds mentioned, they are found in reptiles, amphibia, and some fishes. They are mostly situated in the pelvic region, and possess striated muscle which is paralyzed by curare like the skeletal muscles. In the tailless amphibia (frogs) there is a pair of lymph hearts on the thoracic dorsum as well as in the pelvic region; and with some elongated amphibia, *salamandra maculosa* and *siren lacertina*, eight to twelve lymph hearts exist along the sides of the body and tail, at the junction of the dorsal and ventral body muscles. Finally, in some cheloneans the number of lymph hearts is very great.

Below the birds the lymphatic glands are absent, their place being supplied by lymphoid tissue and by special fine vascular nets or networks into which the vessels break up in their course. Perfect valves like those present in mammals are found in birds, less perfect ones in reptiles and amphibia, and finally in the fish-like forms none at all are found, so that the system may be injected toward the periphery like the arteries.

TOPOGRAPHICAL ANATOMY OF THE LYMPHATICS.—While it would seem more philosophical to treat the various parts of the lymphatic system in their entirety throughout the whole body, viz. the costal, superficial, or subcutaneous; the costal, subaponeurotic or deep; and the visceral lymphatics with the corresponding glands and lymphoid tissue, it is better practically, both for the purposes of demonstration and study, to consider all the lymphatic structures belonging to a given region at one time. This method is also really in accord with nature, because all the lymphatic structures in any reasonably well defined region of the body are, sooner or later, intimately connected and really form one whole for the given region.

Following the plan ordinarily pursued, the lymphatic vessels will be considered as extending in the direction in which their contents flow, as with the veins, and also in the order in which they must be demonstrated by injections. This will require the investigation to commence at the periphery and extend toward the centre. In the descriptions here given, usually only the trunks containing valves will be considered. The origin of the vessels in the tissues and the valveless networks will be considered below, under the origin and relations of the lymphatics. When the term plexus is used in this article it will be restricted to a lymphatic plexus composed of lymphatic glands with their connecting lymphatic vessels, and will not apply to a network of vessels without glands. After the vessels of a region have been described, there will be given a list of the groups of the lymphatic glands and the plexuses belonging to the region, together with the source and destination of the afferent and efferent vessels. This will serve both to give the proper information concerning the number and position of the glands, and also to form a condensed summary of the lymphatic system in the region.

LYMPHATIC VESSELS OF THE HEAD, FACE, AND NECK.—The ectal or subcutaneous lymphatic vessels of the head and face are very abundant and follow, in general, the course of the occipital, temporal, and facial blood-vessels, converging somewhat toward the great vessels of the neck; they traverse one or more of the lymphatic glands which form an irregular zone nearly around the base of the head (Fig. 4974), and finally enter the internal jugular plexus, and terminate in the thoracic duct on the left, or the common lymphatic trunk on the right (Fig. 4990). In addition to the general description just given, the lymphatics of the eyelids, nose, and ear require special mention.

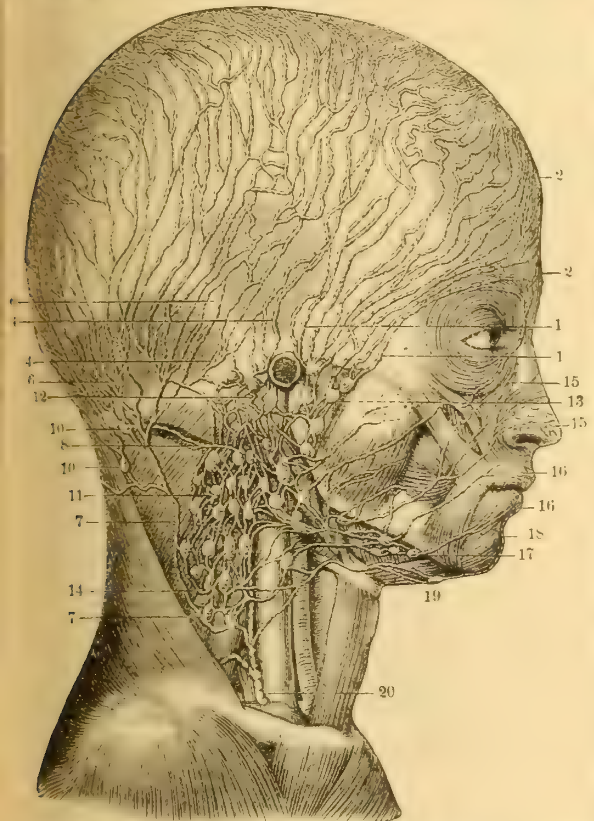


FIG. 4974.—Ectal Lymphatics of the Head and Face, the Ental Lymphatics of the Neck, and the Right Common Lymphatic Trunk. (Sappey.) 1, 1 Lymphatics from the frontal region going to the parotid lymphatic glands; 2, 2, vessels arising near the middle of the forehead, the upper ones going to the parotid, the lower ones to the submaxillary lymphatic glands; 4, 4, vessels from the parietal and temporal region extend to the mastoid lymphatic glands; 6, 6, vessels from the parietal and occipital region joining the occipital plexus; 7, trunk from occipital plexus to the supra-clavicular glands; 8, trunk from the occipital to the cephalic, ental (superior deep) cervical glands; 10, 10, occipital lymphatic glands; 11, cephalic ental (superior deep) cervical glands and plexus; 12, mastoid glands; 13, parotid lymphatic glands; 14, part of supra-clavicular glands; 15, 15, lymph vessels from the nose to the submaxillary glands; 16, 16, lymphatics from the lips to the same glands; 17, submaxillary glands; 18, vessel from the lip to 19, the supra-hyoid gland; 20, right common lymphatic trunk opening into the veins at the angle formed by the junction of the subclavian and internal jugular veins.

The lymphatics of the eyelids and palpebral conjunctiva form a very abundant network, although it is somewhat difficult to demonstrate. Those from the conjunctiva wind round the edges of the lids and mingle with those of the integument, which are especially abundant at the edges of the lids. The branches unite into two great groups at the canthi of the lids, those at the lateral canthus extending to the parotid lymphatic glands, while those at the nasal canthus join those from the middle of the forehead and the nose, and extend to the submaxillary lymphatic glands (Fig. 4974).

The skin of the nose, especially the thicker part around the tip, where the large sebaceous glands are so abundant, is possessed of a very dense network of lymph capillaries and minute trunks. These trunks are joined by the abundant lymphatics from the vestibule, which in turn are continuous with the lymphatics of the nasal mucosa. Finally, the collecting trunks from the vestibule and the nasal integument extend obliquely across the face to the submaxillary lymphatic glands.

The lymphatics of the external ear and meatus form three principal groups: 1. Those of the helix, antihelix, and convex (posterior) surface. Those of the helix and antihelix wind round the free border of the ear to the convex surface, where they join the trunks of that surface, and uniting into several (4 to 5) considerable vessels, they extend to the mastoid lymphatic glands. 2. The lymphatics of the external auditory meatus, also the membrana tympani (see below), the concha and tragus, terminate by two or three trunks in the parotid lymphatic glands. 3. The lymphatics of the lobule unite into seven or eight considerable trunks which extend to the caudal or lower of the mastoid lymphatic glands.

Ental Lymphatics of the Face and Head.—These are exceedingly abundant, and extend mostly to the deep cervical glands, but the relations of the vessels and the terminal glands are so various that a special description is required for each of the principal organs. Nasal cavities and sinuses opening into them: The existence of lymphatic vessels in the nasal mucosa was not demonstrated until 1859, when E. Simon showed by successful puncture injections that they were numerous. He also showed their relation with the network of the naso-pharynx. The existence of these vessels has been verified by Sappey in man and numerous animals. According to Sappey, the demonstration is comparatively easy wherever the mucosa is of considerable thickness. Schwalbe, and later Key and Retzius, showed that the nasal lymphatics could be injected from the subdural space; Key and Retzius[2] further showed that the injection was equally successful from the subarachnoid space of the brain, the subarachnoid and subdural spaces of the myel (spinal cord). They also found that, while in most cases the perineural sheaths of the olfactory nerves were injected at the same time, yet true lymphatic vessels did not communicate with these, but had special passages through the lamina cribrosa, and were often injected when the perineural sheaths were not injected; and sometimes the perineural sheaths were injected without the injection of the lymphatics. They were not successful in injecting the nasal lymphatics of man from the cranial lymph-spaces, although the perineural sheaths of the olfactory nerves were in some cases filled. The freshly sacrificed dog and rabbit furnished the most successful preparations. The lack of success in man was attributed to the inability to obtain sufficiently fresh material; it was also suggested that in man the lymph from the cranial lymph-spaces might have a sufficient number of other outlets.

The lymphatic network covers the entire nasal mucosa, both on the olfactory and the respiratory part, and that lining the septum. In man this network is directly continuous with that of the vestibule of the nose, but the collecting trunks extend toward the pharynx. The network is also continued into the frontal, and presumably the other, sinuses opening into the nasal fossæ. As they approach the pharynx, the collecting trunks of the nasal mucosa are continuous with those of the dorsal surface of the soft palate and of the pharynx, especially the dense network around the Eustachian orifice. From these situations the collecting trunks accompany those of the soft palate and the pharynx sending one trunk through the wall of the pharynx, to the large lymphatic gland instead of its true (or the position of the atlas; see Fig. 3300). This gland, according to Sappey, is the most constant lymphatic gland in the body, and becomes involved in diseases of both the nose and the pharynx. The upper trunk traverses the pharyngeal wall, and extends along [illegible] to the level of the [illegible] muscle [illegible] nerve, where it [illegible] the deep cervical glands covered by the sterno-mastoid muscle at this point. Not rarely, also, several [illegible] join the [illegible] trunks, which, having the posterior pillars of the fauces, end in the deep cervical glands by the thyrohyoid [illegible] (Plate XXVIII., III.). In the dog all the lymphatics from the nasal mucous are known to join and descend in reaching the deep cervical glands (3, 4, of Fig. 3300). Sappey figures and describes the exceedingly abundant lymphatics of the nasal mucosa in the [illegible] and [illegible]. In both these animals, but especially in the horse, the lymphatics of the mucous lining the nasal septum are very abundant, and in both animals, besides the trunks extending toward the pharynx, there are large trunks extending toward the nostrils, where they become subcutaneous, and extend with the facial vessels to the submaxillary lymphatic glands.

Lymphatics of the Eye and the Orbit.—The lymphatics of the conjunctiva extend around the edge of the eyelid, and join those of the integument as described above, and finally reach the parotid and submaxillary lymphatic glands. Sappey denies the presence of lymphatics in the eyeball itself; but most anatomists consider that, while the eye may not be supplied with numerous independently walled lymphatics, nevertheless it is abundantly supplied with lymph-passages, etc., many of which have no endothelial lining. The lymph-channels of the cornea, which are exceedingly abundant, following the nerves as well as the corneal corpuscles and their communicating processes, communicate with the conjunctival vessels, and also with the lymph-clefts of the sclerotic; the aqueous chamber also communicates indirectly with the conjunctival lymphatics through the cornea. In the [illegible] have been described distinct anastomosing lymphatic vessels by Altmann, and their presence has been lately confirmed by one of his pupils.

The retinal blood-vessels are well supplied with perivascular lymph-spaces like those of the central nervous system, and may be injected from the lymph-spaces of the optic nerve. Both chambers of the eye and the perichoroidal, and the space enclosed by the capsule of Tenon, and the lymph-spaces of the optic nerve, all communicate; and as shown above, the corneal spaces and the aqueous chamber through the cornea communicate on the one hand with the conjunctival lymphatics and on the other with the lymph-clefts in the sclerotic. In accordance with this complicated relation of the lymph-passages of the eye, the lymph-streams have been likewise found of equal complexity—passing from the vitreous to the papilla, and along the central canal of the optic nerve, with the blood-vessels, and ultimately reaching the cranial cavity. This has been shown to be the direction in the cat, dog, rabbit, and guinea-pig, and is supposed to be also the case in man. There is also a stream flowing from the subarachnoid and subdural spaces in the cranium, which follows the prolongations of these spaces around the optic nerve; these finally reach the eye and communicate with its various lymph-spaces, and through the perichoroidal space with the lymph-space in the capsule of Tenon, and presumably through this with the lymphatic vessels in the orbit. That is, there is a lymph-stream flowing from the eye to the cranial cavity, and another from the cranial cavity back to the eye through a different channel. If the assumption is correct, that the lymphatics of the eyeball communicate through the capsule of Tenon with the lymphatics of the structures in the orbit, their destination is to the lymphatic glands of the [illegible] group in the [illegible]. Toward the cranial cavity the lymph from the eye mingles with the lymph of the subarachnoid and subdural spaces to one point, with which these spaces communicate.

Lymphatics of the Ear.—The lymphatics of the membrana tympani are like the blood-vessels in three layers, corresponding to the cutis, the mucosa, and the intermediate fibrous framework. They extend to the external auditory meatus and, joining those, finally enter the parotid lymphatic glands, as described above for the external ear. Those of the tympanum or middle ear are numerous, but apparently confined mostly to the submucosa. They are directly continuous with the lymphatics of the Eustachian tube, and extend with them to the abundant network in the pharynx around the Eustachian orifice, and finally extend to the [illegible] cervical lymphatic glands. The lymphatics of the internal ear consist entirely of spaces which are in communication with the subarachnoid and subdural spaces through the perineural spaces of the auditory nerve, thus agreeing with the eye and nose.

Lymphatics of the Mouth, Pharynx, and Larynx.—The intimate relations of the lymphatic network in these regions, their connection with the nose, and through the nose with the cranial lymph-spaces, with the middle ear, [illegible] and trachea, and the varied terminations of the collecting trunks, give the lymphatics of this group an especial anatomical interest. They are not less important pathologically from their involvement in the grave disorders of the mouth, nose, and throat.

The lymphatic network of the buccal mucosa, gums, [illegible], and that of the mouth, palate, and pharynx, may be said to be continuous but the collecting trunks in different regions have quite different destinations. At the lips the network is also continuous with that of the integument, but the course of the lymph-stream is away from the lips. For the gums of the maxilla or upper jaw, the lymphatics extend between the teeth and join those of the mucosa of the cheek; these follow in general the contour of the jaw and penetrate the cheek at various points, extend in part to the parotid lymphatic glands, but mostly to the submaxillary glands. Near the pharynx they join the palatine lymphatics (Fig. 3307).

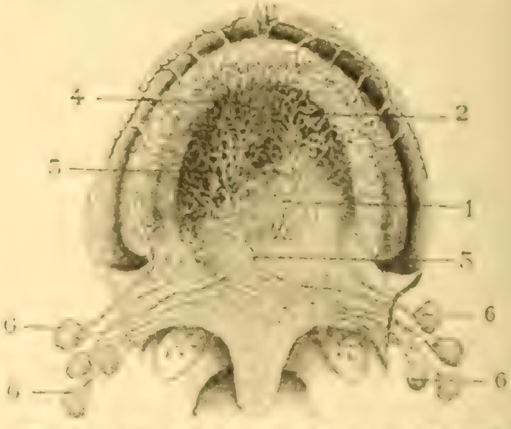


Fig. 3307.—Lymphatics of the Roof of the Mouth and the Gums in a [illegible] (Sappey, [illegible].) [illegible]

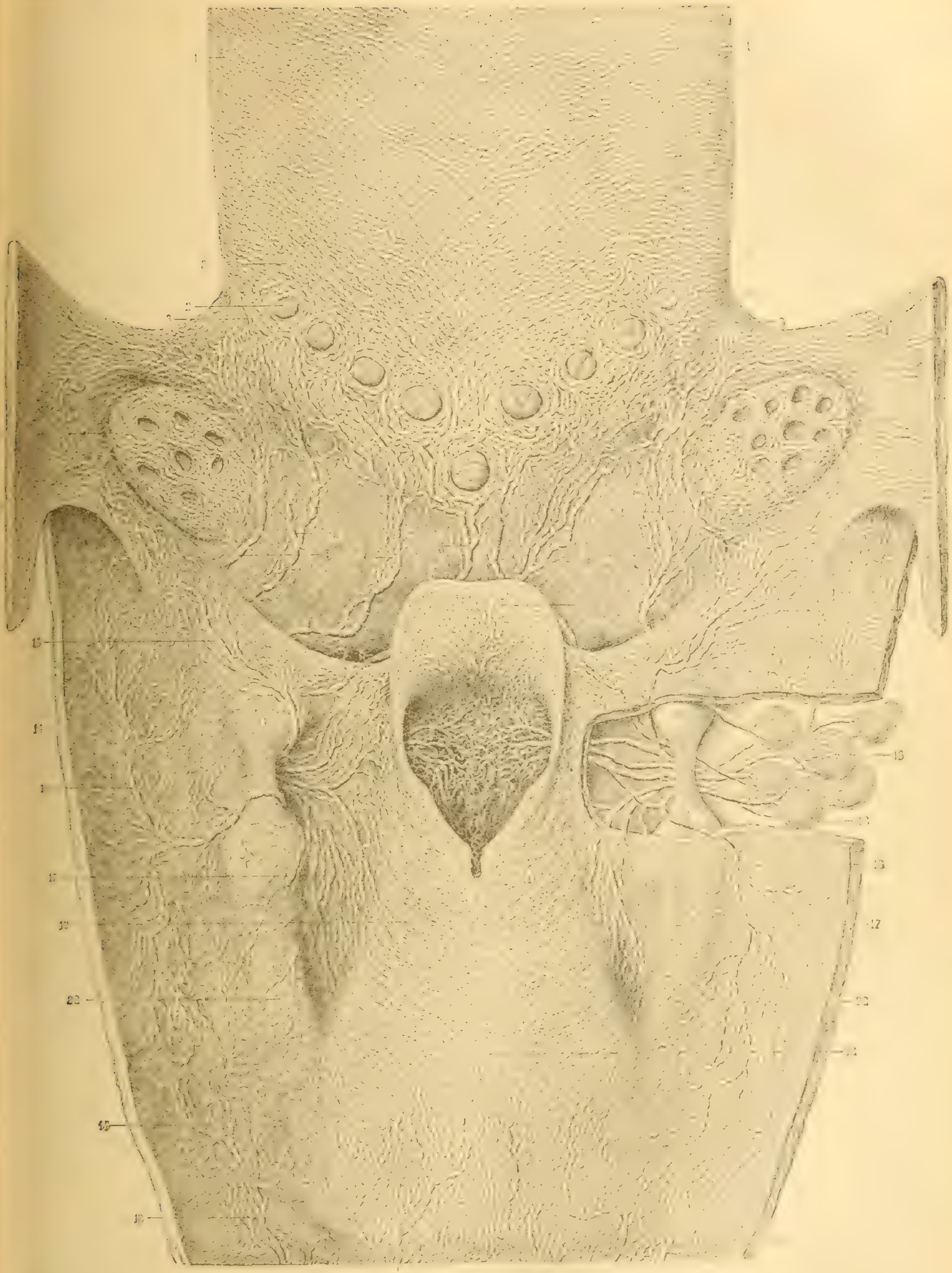
A large number of those from the gums of the mandible or lower jaw join the lymphatics of the cheek and extend to the submaxillary lymphatic glands. A part also join those of the pillars of the fauces.

The lymphatics of the hard and soft palate, while directly continuous with those of the gums, have a direction toward the pharynx, the trunks of the two sides often crossing. They join those of the pillars of the

EXPLANATION OF PLATE XXXIII.

WHICH REPRESENTS THE BASE OF THE TONGUE, THE TONSILS, THE PHARYNX, AND THE OPENING OF THE LARYNX OF MAN. THE PHARYNX WAS DIVIDED ON THE DORSAL SIDE, AND THE WALLS REFLECTED. (Sappey, "Atlas.")

1, 1, Lymphatic network on the dorsum of the tongue, the general direction of the vessels is obliquely toward the fauces (isthmus) and the base of the tongue; 2, 2, circumvallate papillæ in the form of a **V**; 3, 3, 3, 3, vessels surrounding these papillæ and soon converging to form mesal and lateral trunks; 4, 4, lymphatic trunks extending along the meson from the middle circumvallate papilla; 5, 5, continuation of 4, one on each side of the middle glosso-glottic fold; and finally penetrating the lateral fold, they enter the lymphatic glands (13) of the ental cervical plexus near the lateral thyro-hyoid ligament; 6, 6, other trunks farther from the meson, taking the same course; 7, 7, lateral trunks from the base of the tongue, tonsil, etc.; they penetrate the pharyngeal mucosa and terminate in the same group of glands, but cross the dorsal instead of the ventral surface of the great cornu of the hyoid; 8, 8, trunks coming from the anterior pillars of the fauces, skirting the edge of the tonsils, and finally entering the cephalic, ental (superior deep) cervical lymphatic glands; 9, 9, the tonsils covered by a dense network of lymphatics; 10, 10, 10, 10, the reflected sides of the arch of the palate (just below the "10" on each side is the divided uvula); 11, dense lymphatic network covering the epiglottis and extending upon the aryteno-epiglottic folds; 12, 12, a similar very dense and fine network of lymphatics upon the pharyngeal mucosa covering the larynx; 13, 13, several lymphatic glands belonging to the cephalic, ental (superior deep) cervical lymphatic glands, situated at the level of the thyro-hyoid ligament; as is evident from the plate, they receive the trunks from the base of the tongue, part of the palatine arch, the tonsils, the larynx and a great part of the pharynx; 14, lymphatics arising from the ventral and lateral part of the pharynx; 15, 15, lymphatics from the posterior pillars of the fauces, they wind round the ventral edge of the great cornu of the hyoid and enter the deep cervical glands at 13, 13; 16, 16, lymphatics arising from the dorsal and lateral aspect of the pharynx and extending to the cervical glands at 13, 13; 17, 17, lymphatic trunks on each side of the larynx to the ental cervical glands at 13, 13; 18, 18, lymphatics from the dorsal and lateral wall of the pharynx next the œsophagus; they extend toward the thorax and enter the chain of ental cervical glands along the trachea and œsophagus; 19, 19, lymphatics from the ventral part of the pharynx, and extending to the chain of ental cervical glands in company with 18; 20, summit of the great cornu of the hyoid exposed by the removal of the pharyngeal wall; 21, end of the major horn of the thyroid, connected with the hyoid by the thyro-hyoid ligament; 22, 22, dorsal border of the thyroid showing through the pharyngeal wall.



BASE OF THE TONGUE, THE TONSILS, PHARYNX, AND OPENING OF THE LARYNX OF MAN.

(SAPPEY, ATLAS.)

fauces, and go with them to the ental cervical glands near the larynx (Fig. 4975; Plate XXXIII.). Some also extend to the glands near the bifurcation of the common carotid with the trunks from the soft palate (Fig. 4975). The lymphatics of the soft palate on the pharyngeal or superior surface are only moderately developed, and communicate with those from the nose and from the Eustachian tube; the collecting trunks extend in part along the posterior pillar of the fauces to enter the glands along the larynx (Plate XXXIII., 13). But a greater number of collecting trunks pass laterad and penetrate the pharyngeal walls to enter the gland on the ventral aspect of the atlas. The ventral or lower face of the soft palate differs from the dorsal or upper face in having a greater number of lymphatic vessels, and the uvula is so richly supplied that it appears almost like erectile tissue, increasing two or three times in volume when successfully injected. The collecting trunks from the uvula and ventral aspect of the soft palate extend along the two pillars of the fauces, and join the trunks from the base of the tongue; but the greater number pass laterad through the wall of the pharynx and extend to the ental cervical lymphatic glands around the bifurcation of the common carotid.

The lymphatics of the tongue escaped discovery until 1847, when Sappey demonstrated them. They are difficult to demonstrate in the adult on account of the number and calibre of the veins, but in the infant and child the veins cause less trouble, and the lymphatics are easily injected. They form a rich network over the entire free surface to a point slightly beyond the circumvallate papillæ. Around the circumvallate papillæ they reach their greatest development. Up to the present no lymphatics have been demonstrated as arising in the substance of the tongue itself, the vessels traversing the tongue being collecting trunks from the mucosa. Around the edges of the tongue the network of the dorsal and ventral surfaces freely anastomose. But the main course of the collecting truncules is toward the middle, on the dorsal side, and toward the base. A few small trunks penetrate the tongue and after traversing the lingual glands, when those are present, extend to the ental cervical glands near the bifurcation of the common carotid. Most of the trunks, however, continue along the dorsum of the tongue, unite into large trunks beyond the circumvallate papillæ, and extend in a wide curve to the ental cervical lymphatic glands situated near the thyro-hyoid ligament (Plate XXXIII., 13). The lymphatics on the ventral side of the tongue extend mostly through the substance of the organ, traversing the lingual glands when present, and finally extend with those which penetrate from the dorsal side, to the lymphatic glands around the bifurcation of the common carotid.

The tonsils, although composed of lymphoid tissue, were not shown to possess a lymphatic network until Sappey succeeded in demonstrating it, in 1876. This network, which covers the surface and extends into the depths of the tissue, is much more easily injected in the new-born child than in the adult. The network anastomoses with that of all the surrounding structures, and the collecting trunks pass with those from the tongue and pillars of the fauces to the glands next the thyro-hyoid ligament (Plate XXXIII.). The lymphatics of the pharynx also resisted demonstration for a long time. They were found by Sappey to be directly continuous with those of the bordering structures, and while the trunks all communicate at their origin, there are three groups on each side: 1. A dorsal group extending along the dorsal or posterior wall of the pharynx nearly to the postnares, and then turning laterad and penetrating the pharyngeal wall, enters the gland on the ventral side of the atlas. 2. Several lateral trunks which extend along the side of the larynx and enter the lymphatic glands near the thyro-hyoid ligament. 3. Several ventral trunks extending mostly in a caudal (inferior) direction to join the supra-clavicular lymphatic glands along the œsophagus and trachea.

Larynx.—The lymphatics of the larynx form one of the densest networks known in the body. Commencing with the epiglottis and the entire opening, the number is almost infinite, the appearance being as if all the soft structures were composed of nothing but lymphatics. With the infant the abundance of lymphatics is continued without interruption along the trachea; but as age advances, the network in the larynx quite suddenly diminishes, so that, commencing with the vocal cords, the network in the larynx and trachea is comparatively slight. From the epiglottis, vestibule of the larynx, the sinus or ventricle, and the vocal cords, collecting trunks extend through the lateral wall of the vestibule, perforate the thyro-hyoid membrane, and terminate in the ental cervical glands beside the larynx (Pl. XXXIII., 13).

Lymphatics of the Central Nervous System.—The spaces and membranes of the brain and the myel are so directly continuous that a discussion of the lymphatics of both seems desirable. Sappey denies lymphatics to the entire nervous system, both central and peripheral, but this is not in accordance with most observers who have made special investigations upon the subject. It is true that independent vessels with definite walls are not found to exist in the nervous substance proper; but from the investigations of Kölliker, Virchow, Robin,[5] and Key and Retzius, it has been shown that, in the nervous substance of the brain and myel, the blood-vessels ramifying in it are possessed of a loose adventitia which is continued from the pia, the so-called pial funnels; and in the meshes of this adventitia are long spaces, like those around the blood-vessels of reptiles. It is supposed that these communicating spaces form the lymph-passages of the nervous substance. They may be injected for a considerable distance into the nervous substance from the subarachnoid space, and injections by the puncture method into the nervous matter not infrequently fill these passages, and extend into the subarachnoid space. After reviewing carefully all the evidence, Key and Retzius[2] consider the perivascular space of His—that is, a space entirely outside all the walls of the blood-vessel—as an artefact, as is also the presence of a subpial lymph-space into which it opens. From the stand-point of Key and Retzius, then, the nervous matter of the central nervous system is drained of its lymph through the adventitial lymph-spaces of its blood-vessels, and these spaces open into the subarachnoid space.

The lymphatics of the meninges are still in some doubt. In the dura there are wide-meshed, often ampulliform, vessels with endothelial walls that are supposed by some to be true lymphatics. Although their form is so strikingly like lymph-vessels, Key and Retzius found, on making the crucial test, that they communicate with the blood-vessels and do not extend to lymphatic glands. There are, however, in the dura a great number of elongated clefts which are probably lymph-clefts or channels. In the pia a very distinct and undoubted network of lymph-vessels has been described and figured. It is probably largely through these that the lymph of the subdural and subarachnoid spaces is drained away.

The subarachnoid space communicates directly with the neurocœle through the foramen of Magendie, and both the subarachnoid and subdural spaces of the optic, auditory, and olfactory nerves, and, in fact, all the nerves arising from the brain and myel, except that in the ordinary nerves the arachnoid as a special membrane soon disappears, and the subdural and subarachnoid spaces become one.

The ento-cranial lymphatics converge to form larger and larger trunks. Those from the vascular plexuses or telas accompany the *vena magna Galeni* to the base of the brain, where they are joined by the lymphatic trunks from the surface of the brain. The combined trunks follow the great blood-vessels out of the cranial cavity mostly through the jugular foramen, and enter the ental cervical lymphatic glands. Small trunks are described as traversing the spinous and oval foramina with the middle meningeal vessels, finally to enter the ental cervical glands in the spheno-maxillary fossa; but the existence of these lymphatic trunks is disputed.

As stated, the subarachnoid and subdural spaces of the brain are directly continuous with the corresponding sponse of the larynx and has been projected and with the … most completely with the optic, auditory, and olfactory, and in this way communication is gained with the lymphatics of the structures to which the nerves are distributed.

The exact relations of the intraspinal lymphatics do not seem to have been well worked out, but they are described as following the blood-vessels, and terminating in the glands in course of the blood-vessels which they follow. The lymphatics of the central nervous system are related to all great groups of glands in the neck and trunk.

Lymphatics of the Neck.—These are ectal and ental, and include the lymphatics of the structures of the neck proper and that of the lymphs from the head and face. The vessels from the integument extend mostly to the ectal cervical glands, but part of them reach the supraclavicular glands directly (see 10 of Fig. 4997).

LYMPHATIC GLANDS OF THE HEAD AND NECK.—These are very numerous and important. They are all continued

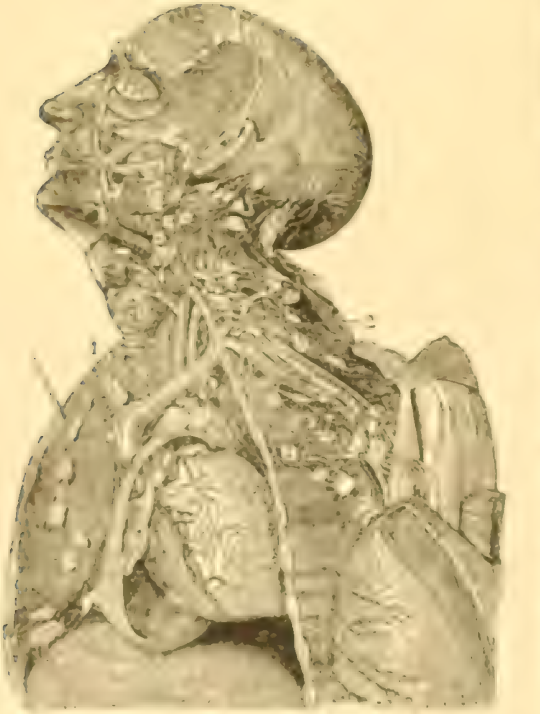


FIG. [illegible] [illegible]

to the sides of the face, around the base of the head, some having been found within the skull, and along the great cervical blood-vessels. They have been divided into two great paired groups or plexuses, the ectal or external, and the ental or internal jugular lymphatic plexuses, the ectal jugular plexus including all the ectal glands and finally emptying its lymph into the ental plexus, which includes all the ental cervical glands. This, while intercommunicating with the glands in the thorax and axilla, sends a main efferent trunk, forming commonly, to join the thoracic duct on the left, the common lymphatic trunk on the right; or it may reach the jugular veins, quite partly or wholly independently to the veins (8 and 9 of Fig. 4995). These plexuses form a kind of double and closely connected chain along the course of the great cervical vessels, and yet, for convenience of description and reference, they have been described as several groups; but here, as in other parts of the body of man, the groups merge so insensibly into each other that the same gland might be placed in one group by one anatomist and in the adjoining group by another. Furthermore, it should not be lost sight of that from a limited region lymphatics may go to quite widely separated groups of glands, and also that the number and size of the glands in a group are subject to considerable individual variation.

The ectal glands of the head and neck, i.e., the glands of the ectal or external jugular lymphatic plexus, are divided into the five following groups:

1. The occipital lymphatic glands (*glandulæ lymphaticæ occipitales s. suboccipitales*), one or two, usually small glands on the complexus muscle between the cranial attachment of the trapezius and the sternomastoideus. The afferent vessels are from the occipital, partly also from the temporal and parietal regions; the efferent vessels extend partly to the ectal cervical, and partly to the supraclavicular glands (Figs. 4994 and 4995).

2. Parotid lymphatic glands (*glandulæ lymphaticæ parotideæ s. auriculares anteriores s. faciales superficiales s. superficiales*). There are usually 10–12 of these on the surface and in the substance of the parotid salivary gland. The afferent vessels are from the temporal and frontal regions, the sides of the face, lateral part of the eyelids and conjunctiva, concha, tragus, [illegible] and external auditory meatus of the ear; from part of the mucosa of the cheeks and the gums of the maxilla or upper jaw. The efferent vessels pass to the submaxillary and ectal cervical lymphatic glands.

3. Mastoid lymphatic glands (*glandulæ lymphaticæ mastoideæ s. retroauriculares s. auriculares posteriores*). Several small glands on the cranial attachment of the sternomastoid muscle, near the mastoid process and base of the ear. The afferent vessels are from the parietal, temporal, and occipital regions in part, from the helix, antihelix, convex surface, and lobule of the ear. The efferent vessels extend to the ectal and ental cervical glands.

4. Submaxillary lymphatic glands (*glandulæ submaxillares*). There are several of these extending along almost the entire extent of the body of the mandible. In this group is included the glands on the buccinator muscle, sometimes described as a separate group (*glandulæ buccales s. buccinatorii*) and sometimes classed with the ectal glands. The submaxillary glands extending near the chin are also sometimes called submental, and a single one near the mesal has been named suprahyoid by Sappey. The afferent vessels of this group are from the middle of the forehead, the nasal portion of the eye, the integument of the nose and vestibule, and in the horse and ox also partly from the nasal fossæ; from the cheeks and lips, the gums of the mandible in part, and the floor of the mouth; part of the efferent vessels from the parotid lymphatic glands; the efferent vessels pass to the ental and ectal cervical glands.

5. Ectal cervical lymphatic glands (*glandulæ lymphaticæ cervicales ectales s. superficiales, s. jugulares externæ*). Several small glands along the ectal jugular vein, but extending on both sides of it. They are between the platysma and the sternomastoid muscle. The afferent vessels are from the ectal structures of the neck, part of the efferent vessels from the occipital, parotid, mastoid, and submaxillary groups; efferent vessels extend to the supraclavicular glands.

The ectal or external jugular lymphatic plexus in the larger herbivora—horse and ox—is approximately like that of man; but in the rabbit it is represented only by the submaxillary lymphatic glands and two small glands near the ear (3 and 4 of Fig. 4997). In the dog only the submaxillary lymphatic glands seem to belong to this plexus (3 of Figs. 4996 and 4998). In the cat the mastoid glands are large and may be injected from the inner or concave aspect of the external ear. It is possible that the small gland on the trunk following the external jugular vein, shown in Fig. 4998, may also belong to the ectal plexus. One cannot help being struck with the fewness of the glands in the dog, cat, and rabbit.

The ental glands of the head and neck, or the glands of the ental jugular plexus are situated on the course of the great vascular trunks and extend from the atlas to the thorax. The lymphatics of the entire head and neck ultimately traverse this plexus.

The glands of this plexus have been quite commonly divided into three great groups, with some minor groups —the deep facial, the superior and inferior deep cervical; but in actual descriptions of the lymphatics of the various organs the anatomists of the present day, although they recognize three groups, and some of them minor groups, actually divide all the glands of the ental jugular plexus into two groups, viz., those extending from the level of the base of the cranium, along the deep vessels, to the bifurcation of the common carotid, and those from the bifurcation of the carotid to the junction of the jugular and subclavian veins. This division was adopted in the previous description, and has been called (1) ental cervical, and (2) supraclavicular. (1) Ental cervical lymphatic glands (*glandulæ lymphaticæ cervicales entales, s. profundæ, s. glandulæ lymphaticæ jugulares cephalicæ*). The ental cervical, or jugular group of glands, includes all the ental glands around the deep structures from the bifurcation of the common carotid artery nearly to the base of the skull, and includes the glands on the internal maxillary vessels in the sphenomaxillary fossa, which are usually given a separate group under the name of deep facial or internal parotid, etc. It also includes the glands generally grouped as the superior jugular or superior deep cervical.

The glands in this group are numerous and quite widely separated from one another, extending from the ventral face of the atlas to the side of the larynx, being about as variously arranged as the organs of this region. The one between the atlas and pharynx is said to be the most cephalic of all the lymphatic glands of the body.

The afferent vessels of this group are from the orbit, nasal cavity, the cheeks, roof and floor of the mouth, in part from the tongue, pharynx, tonsils, tympanum, and Eustachian tube, the larynx, the thyroid, and the brain and its membranes. The efferent vessels pass to the supraclavicular glands.

(2) The supraclavicular glands (*glandulæ lymphaticæ supraclaviculares, s. cervicales profundæ inferiores, s. jugulares inferiores*). These glands are arranged along the carotid artery and internal jugular vein from the bifurcation of the common carotid to the junction of the subclavian and internal jugular veins. All the efferent trunks from the ectal jugular plexus and from the ental cervical glands enter this group, also many of the lymphatics of the pharynx, œsophagus, trachea, the lymphatics accompanying the vertebral artery and vein, also some of the ectal and ental lymphatics of the neck and the clavicular region. They also communicate with the anterior mediastinal and with the axillary glands. The efferent vessels form a single or multiple trunk (*truncus lymphaticus jugularis*) and terminate on the left in the thoracic duct, or on the right in the right common lymphatic trunk, or sometimes partly or wholly by an independent opening into the great veins (Figs. 4974 and 4994).

In the horse and ox the glands of the neck are approximately like those of man; but in the cat, dog, and rabbit there is but a single ental cervical lymphatic gland, and the jugular trunk is usually large and long, and not infrequently opens partly or wholly into the vein independently (Figs. 4993, 4994, 4996, and 4998).

Lymphatic Vessels of the Thoracic Limb (*Arm and Shoulder*).—The lymphatics of the arm and shoulder form an ectal and ental set, as in most parts of the body. The lymphatics of the hand arise by a complex net-work on the dorsal and palmar surface of the fingers, and extend toward each side of the finger, where they unite into two or three anastomosing trunks which follow the direction of the collateral arteries to the hand when they reach the dorsal surface. From the palm many vessels wind round both edges to the dorsal side also; but many next the wrist extend directly upon the ventral or flexor aspect of the arm and extend to the axillary region. The trunks on the dorsum of the hand and the extensor side of the entire arm gradually wind round to the flexor surface in their course to the axilla. Most of the vessels enter directly the axillary glands, but a few of those from the fourth and fifth fingers and the ulnar side of the anti-brachium traverse one or two glands (ectal brachial or supra-epitrochlear glands in the flexure of the elbow, Fig. 4978) before proceeding to the axillary glands. Frequently, if not constantly, one or more trunks follow the cephalic vein and go to the subclavian glands instead of going to the axilla, and not infrequently there is a gland in the course of these near the insertion of the deltoid, or even farther along (13 of Fig. 4978; see also Fig. 4980). The ectal lymphatics of the shoulder either join the trunk following the cephalic vein or extend round to the axilla. The ental lymphatics of the arm arise in the deep structures and follow the principal blood-vessels much more closely than do the ectal lymphatics. In the antibrachium there are, therefore, three groups following the radial, ulnar, and interosseous blood-vessels. There are occasionally a few small lymphatic glands in the antibrachium (antibrachial glands) through which a part of the vessels pass; but usually none are reached until in the flexure of the elbow, where, extending along the brachial vessels, there are regularly met three or four glands (ental or deep brachial glands), which most of the vessels traverse. Before reaching the axillary glands, according to most authors, there is a free anastomosis between the ectal and ental lymphatics at the wrist and elbow, but Sappey denies any such anastomosis.

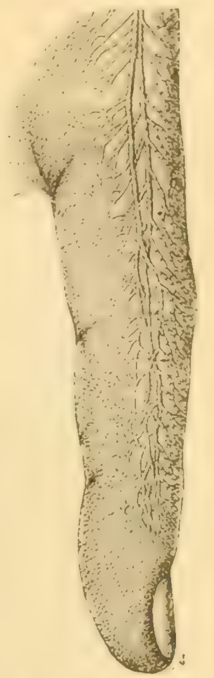


FIG. 4977.—Ectal Lymphatics of a Finger. (Sappey.) To show the extreme abundance of the lymphatics and the fineness of the net work on the end and the palmar aspect, also that the vessels from both the dorsal and ventral surfaces extend to the side where two or three considerable trunks, parallel with the collateral artery, convey the lymph toward the hand. By comparing Fig. 4978, it will be seen that these trunks always extend upon the dorsum of the hand.

According to the description of most veterinarians, the lymphatics of the arm and shoulder of the horse and ox are quite comparable with those of man both as to glands and vessels, except that there is a large lymphatic gland in the fold between the scapula and the neck—the prescapular gland. In the dog and cat the arrangement is exceedingly simple. All of the vessels, except a few cutaneous ones whose course is somewhat irregular, which can be injected from the pads of the manus (forepaw), finally extend upon the dorsum of the foot, and extend from there by two or more frequently anastomosing trunks along the radial nerve to the elbow, and then follow the cephalic vein to the prescapular gland, no axillary glands being present (Figs. 4992 and 4995). Occasionally, in the cat, one or more branches turn in the bend of the elbow to follow the brachial vessels to the axilla, and finally enter the nearest pectoral gland.

In the rabbit, vessels likewise follow the radial nerve to the elbow, then extend obliquely around the radial side of the brachium to the axillary glands. Other trunks follow the large blood-vessels, and enter the axillary glands. The lymphatic vessels of the arm, whatever their course, traverse but a single gland in the dog and cat, sometimes two glands in the rabbit.

LYMPHATIC GLANDS OF THE ARM AND SHOULDER. —Ectal brachial glands (*Glandulæ brachiales ectales, s. su-*

ulnarium, s. cubitales superficiales, s. supratrochleares; two glands often found in the course of part of the trunks from the fourth and fifth finger and the ulnar side of the arm. The gland in the course of the trunk following the cephalic vein has not been found.

The volar glands. There are sometimes a few in the antibrachium (*Glandulae lymphaticae antibrachiales*), through which traverse the volar antibrachial lymphatics on their way to the cubital brachial glands (*Glandulae lymphaticae brachiales cubitales s. profundae, s. cubitales profundae s.* [illegible]). These are just proximal of the elbow joint on the brachial vessels. Through these pass part of the volar lymphatics.

The axillary lymphatic glands (*Glandulae lymphaticae axillares*, Fig. 4980) are situated in the axillary region around the great vessels and nerves, are covered by the pectoral muscles and extending from the edge of the great pectoral into the subclavian fossa, where they are in communication with the supraclavicular glands. All the lymphatic vessels of the arm and most of those of the shoulder enter these glands; also many from the supra-umbilical part of the abdomen, side, and back; also the lymphatics of the mammary gland and the other structures of the breast, including the efferent vessels of the pectoral lymphatic glands. The efferent trunk (*truncus subclavius*) is one of the important tributaries of the common lymphatic trunks.

In the dog and cat no axillary glands are present, all the trunks going to the prescapular gland (*glandula praescapularis*) (Figs. 4992, 4996). In the rabbit all go to axillary glands [illegible] (Fig. 4997 and 4998).

Lymphatic Vessels of the Pelvic Limb.—The volar lymphatics of the foot, leg, and thigh are almost precisely like those of the hand and arm. The vessels of the toes and sole extend mostly to the dorsum of the foot and then wind round the leg to the inguinal region and enter the subcutaneous inguinal lymphatic glands (Figs. 4979 and 4980). A limited number of vessels from the heel and fibular side of the foot accompany the short saphenous vein to the popliteal space where they enter the popliteal glands and join the volar lymphatics.

The subaponeurotic or volar lymphatics also resemble those of the arm, following the main vascular trunks; hence in the crus there are three groups: one on the ex-

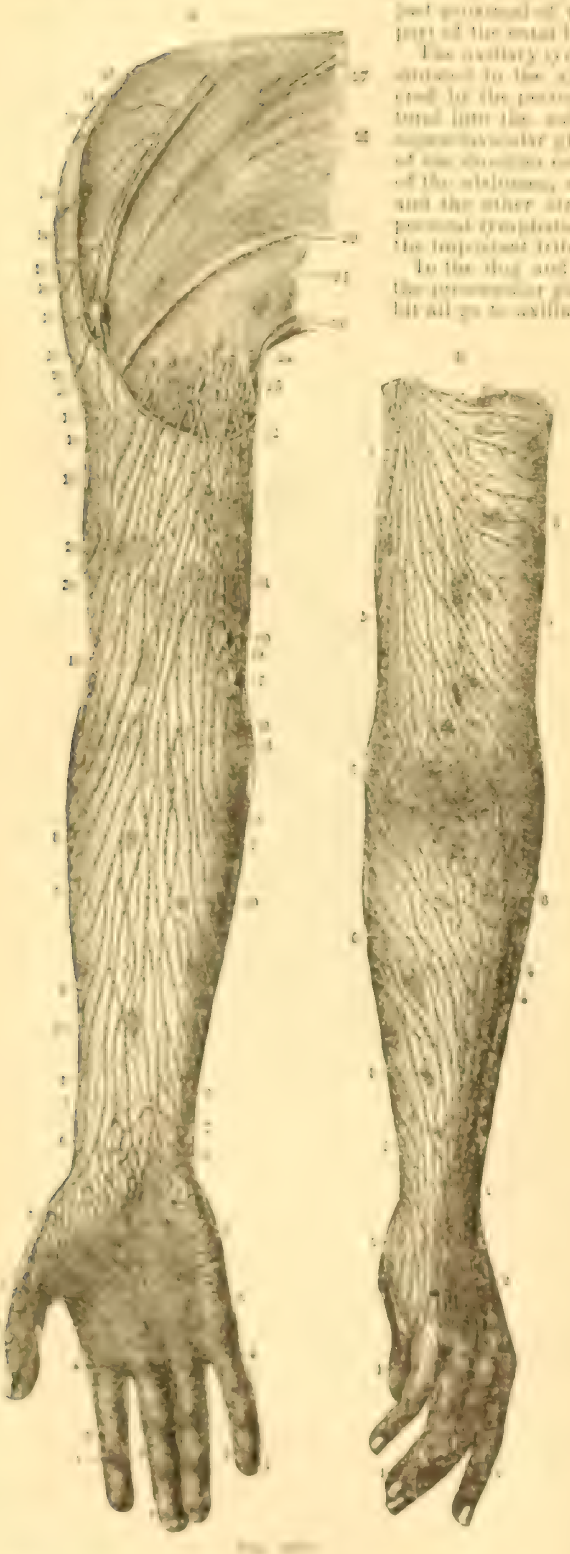


Fig. 4978.

FIG. 4978.—Volar Lymphatics of the Hand and Arm. [illegible]

tensor side of the crus following the anterior tibial vessels, and sometimes traversing one or two anterior tibial glands at about the middle of the crus. The lymphatics penetrate the interosseous ligament near the knee to enter the popliteal glands. The other two groups follow the peroneal and posterior tibial blood-vessels to the popliteal glands. After traversing the popliteal glands the lymphatics follow the femoral vessels to the inguinal region, where they enter the ental inguinal glands and after traversing these accompany the femoral vein and artery into the abdomen to the iliac glands. Besides these there are lymphatic trunks accompanying the sciatic and gluteal vessels, which traverse one or more small glands, gluteal and ischiadic glands, at the sacro-sciatic foramen and then enter the hypogastric glands. The trunk following the obturator artery constantly traverses, according to Cruveilhier, a considerable gland (*glandula foraminis obturatorii*) before entering the hypogastric glands.

In the dog, cat, and rabbit there is the same simplicity of the lymphatic trunks as pointed out for the arm. Injections into the pad of the pes (hind paw) demonstrate vessels on the dorsum and great-toe side of the foot. Part of these trunks follow the course of the long saphenous vein, others, usually larger trunks, wind round the calf, with the short saphenous vein, to the popliteal space and enter a popliteal gland (Figs. 4992, 22). In the rabbit, branches extend to the popliteal space from both sides of the crus (Fig. 4997). From the popliteal gland the main efferent vessels in all pass between the peroneal and tibial nerves, and accompany the femoral artery and vein, freely anastomosing with the trunk along the saphenous artery. No inguinal glands are present, and the vessels extend directly to the lumbar glands (Fig. 4980, 22 and 24).

LYMPHATIC GLANDS IN THE LEG.—The most distal gland is the tibialis anterior, situated on the interosseous ligament near the middle of the crus. Through it pass the ental trunks, following the anterior tibial vessels on their way to the popliteal glands. This gland is frequently absent. The popliteal glands (*Glandulæ popliteæ*, Fig. 4979) are in the fat in the popliteal space. Two are near the surface and receive the lymphatics accompanying the short saphenous vein. Their efferent trunks pass to the two more deeply situated glands around the popliteal blood-vessels ;

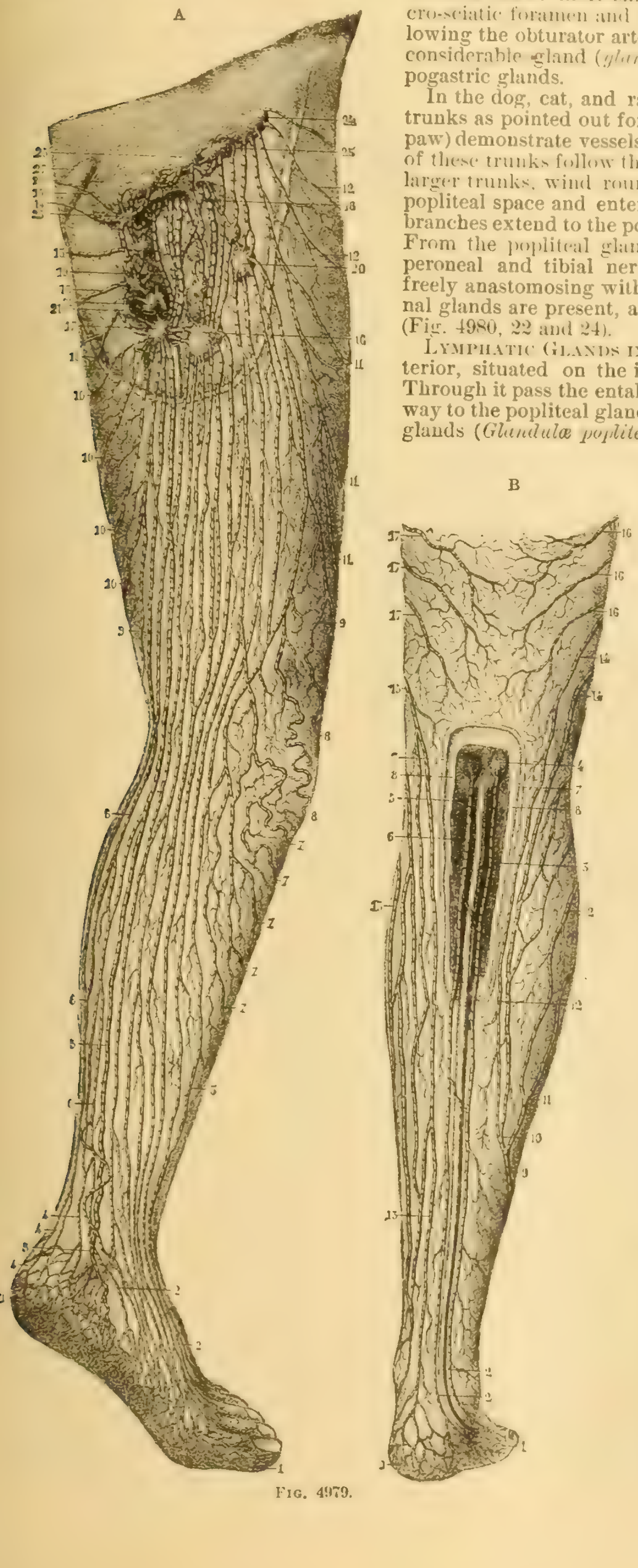


FIG. 4979.

FIG. 4979.—Ectal Lymphatics of the Foot and Leg, to show the Origin, Number, and Course of the Lymphatic Trunks, and the Popliteal and Inguinal Lymphatic Glands. The skin is represented as transparent, except where removed in the popliteal space and in the inguinal region. (Sappey, Atlas. A. The tibial side of the foot and entire leg. 1, 1, Truncules arising from the sole, great toe, and side of the foot ; 2, 2, trunks arising at the toes and extending across the dorsum of the foot to reach the tibial side of the leg ; 3, great trunk arising from the plantar aspect near the instep, and skirting the tibial or internal malleolus on its way to the inguinal region ; 4,4,4, trunks coming from the heel and extending along the ankle and leg ; 5, 5, and 6, 6, trunks extending along the crus parallel with the calf ; 7, 7, 7, 7, trunks winding round the edge of the tibia to reach the tibial or inside of the leg ; 8, 8, lymphatic trunks winding round the knee to reach the inside of the leg. They are very tortuous when the knee is extended, more nearly straight when it is flexed ; 9, 9, trunks curving round from the extensor side of the meros, or thigh, to reach the inguinal glands ; 10, 10, 10, 10, numerous trunks winding round from the flexor side of the thigh to the inguinal glands ; 11, 11, 11, trunks curving round from the extensor side of the thigh to the inguinal glands ; 12, 12, trunks from the gluteal region ; 13, 13, trunks from the perineal and anal region to the inguinal glands ; 14, trunks from the scrotum (cf. Fig. 4980) ; 15, trunk from the penis ; 16, the large distal ganglion of the ectal inguinal group, into which enter so many of the trunks of the leg ; 17, another large gland at the same level ; 18, large efferent trunk from 16 ; it follows the course of the femoral artery ; 19, lymphatic trunks following the course of the femoral vein ; 20, large gland receiving many of the trunks from the extensor sides of the thigh ; 21, gland receiving many of the trunks from the flexor side of the thigh ; 22, 22, cut end of the vena saphena magna ; 23, ganglion in the groin to which extend many of the lymphatics from the penis (cf. Fig. 4980) ; 24, large corner ganglion receiving most of the trunks winding round the ilium from the lumbar and gluteal region ; 25, 25, proximal row of glands in the fold of the groin to which extend many of the trunks from the ventral wall of the abdomen ; 27, inguinal ring with the contained spermatic cord.

B. Flexor Aspect of the Distal Half of the Leg. 1, 1. Trunks from the heel and fibular side of the foot ; 2, 2, two lymphatic trunks following the course of the vena saphena to the popliteal glands ; 3 and 5, the two lymphatic trunks, 3 on the fibular, 5 on the tibial side of the vein ; 6, vena saphena parva ; 7 and 8, cut edge of the skin, and aponeurosis removed to bring the popliteal glands into view ; 9, great trunk on the fibular side of the crus ; it follows the contour of the calf, and by its branches furnishes nearly all the trunks on the fibular or outside of the crus ; 10, 12, bifurcations and branches of 9 ; 13, 13, trunks on the tibial side of the crus. They curve round to the inner side of the leg, and extend to the inguinal glands ; 14 and 16, trunks on the fibular side of the thigh, which wind round to the extensor aspect, and then to the inguinal glands (cf. 11 in A) ; 15, large trunks on the tibial or inside of the knee, on its way from the heel, crus, and thigh, to the inguinal glands ; 16 and 17, trunks winding round the thigh in opposite directions to reach the inguinal glands.

through the deeper ones pass all the [illegible] and [illegible] part of those from the knee. The efferent vessels pass with the femoral blood-vessels to the inguinal glands.

Inguinal glands (Glandulæ lymphaticæ inguinales, Figs. 4979 and 4980).—There are two groups of these, the deep or subinguinal, and the superficial or inguinal.

The superficial inguinal glands, forming an irregular four-sided figure with the border along Poupart's ligament. The afferent vessels are the cutaneous lymphatics of the [illegible] limb, [illegible] part of the body and the external genitalia. The efferent vessels traverse the cribriform [illegible] and enter the deep or subinguinal glands; frequently a few trunks pass into the body cavity and join the iliac glands.

The subinguinal glands are situated along the femoral artery and vein in the [illegible]; they are usually three or four, although in number there may be six or seven. They are covered by the femoral fascia and are in intimate contact with the femoral vessels; one of them is found almost constantly in the [illegible] of the femoral or crural ring, which according to [illegible] it assists in closing. The afferent vessels of this group are derived from the deep lymphatics of the foot, leg and thigh (in part), the efferent trunks from the popliteal and most of those from the subinguinal glands.

A part of the efferent vessels traverse the abdominal wall with the femoral artery, but most of them accompany the femoral vein through the crural canal. They join the iliac glands, sending a few branches, however, to the hypogastric glands.

In the larger domestic animals (horse and ox) the glands of the leg are almost as numerous as in man, but with the cat, dog and rabbit they are represented only by the popliteal gland, the inguinal glands being absent, unless the gland on the external epigastric vessels may represent the subinguinal glands. As the iliac glands are also absent, vessels may pass from the foot (i.e., those accompanying the saphenous artery) directly to the lumbar glands (Figs. 4992, 4995, and 4997).

LYMPHATICS OF THE ABDOMEN AND EXTERNAL GENITALIA.—The cutaneous lymphatics of the abdomen have three quite sharply defined areas of origin, and from these the vessels extend in opposite directions. The areas are the [illegible], the ventral, and a somewhat irregular zone surrounding the body at the level of the umbilicus (Fig. 4980). The vessels cross these boundaries and intercommunicate in a complex manner; frequently a puncture made in the boundary will give rise to an injection in both directions, although injections made at either side would inject only the corresponding side. In the lower [illegible] especially

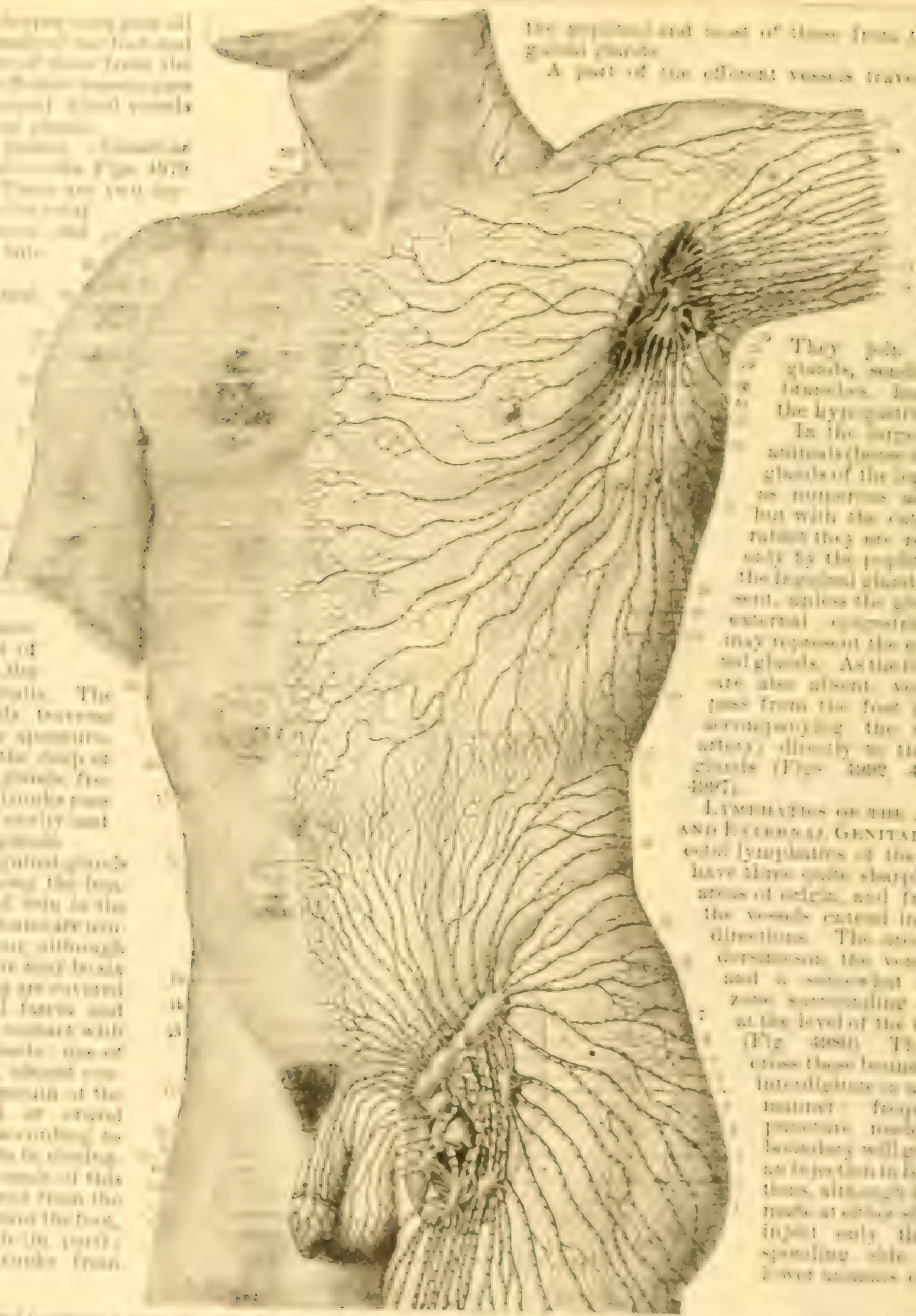


FIG. [illegible].—[illegible]

investigated for this—cat and opossum—the communication from side to side is more intimate, an injection of one side often filling that of the other. This is especially marked opposite the pubis of the opossum, where there is constantly a large transverse lymphatic, recalling the transverse vessels between the jugular veins.

As seen in Fig. 4980, the lymphatics of the subumbilical region of the body extend in the most direct manner on the abdomen to the inguinal or the axillary glands. Those from the lumbar and gluteal regions extend around in great curves, often following the crest of the ilium, to the lateral inguinal glands. Others from the gluteal region curve round the nates to the perineal and anal regions, finally to join the perineal and anal vessels and extend with them to the median glands of the ectal inguinal group.

The lymphatic net-work around the anal opening is very dense and is continuous with the lymphatics of the rectum. Those of the perineum are less dense. From both these regions the vessels wind round the thigh to the median or inner of the ectal inguinal glands. In the female the number of the trunks from the perineum is reduced apparently in direct proportion to the reduction in area of the region. The lymphatics of the external genitalia of the male are naturally divisible into those of the scrotum and the penis. The vessels of the scrotum are very numerous, perhaps more so than in any other equal area of integument in the body. As in the trunk, the meson—here indicated by the raphe—forms a natural dividing line for the two sides. The vessels extend in great curves, partly to the pubis and partly on the thigh, to enter the median row of ectal inguinal lymphatic glands; those on the thigh communicating with the vessels from the perineum, and those of the pubis with the cutaneous vessels of the penis. The vessels of the integument of the penis, commencing on both surfaces of the prepuce and from the line of the urethra, wind round the two sides to the so-called dorsum of the organ when they extend toward the pubis, and curve laterally toward the two sides to enter the large gland forming the corner of the ectal group (Fig. 4981). The lymphatics of the glans penis are exceedingly numerous, and in several superimposed layers of net-works. The collecting trunks converge toward the frænum preputii, where they are joined by the trunks from the urethra.

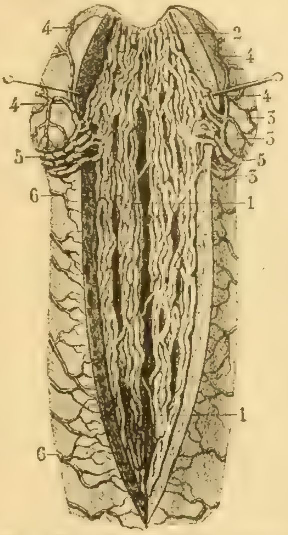


FIG. 4981.—Human Penis, opened Longitudinally to show the Urethral Lymphatics. (Sappey, Atlas.) 1, 1, The very abundant longitudinal net-work of vessels in the urethral mucosa; 2, continuity of the urethral lymphatics with those of the glans at the meatus urinarius; 3, 3, 3, trunks traversing the urethral wall opposite the frænum and joining those of the glans; 4, 4, 4, 4, trunks from the periphery of the glans joining those from the urethra; 5, 5, large trunks formed by the union of the urethral lymphatics and those from the glans, they penetrate the substance of the penis and follow the deep blood-vessels to the pubis, whence, according to Sappey, they extend to the inguinal, but, according to many authors, to the hypogastric lymphatic glands; 6, 6, lymphatics of the integument of the penis.

The urethral lymphatics begin at the prostate, anastomose with the prostatic lymphatics, with the net-work of the ejaculatory canals, and through them with the *vesiculæ seminales*. They extend to the *meatus urinarius*, forming a hollow cylindrical net-work of large, densely packed lymphatics (Fig. 4981), which reaches its greatest development opposite the fossa navicularis. Opposite the frænum two or three trunks penetrate the urethral wall and join the trunks from the glans, then penetrate the substance of the penis and reach the dorsal aspect of the *corpus spongiosum*, where the trunks of the two sides usually unite into one, which follows the course of the deep blood-vessels to the pubis, when it again divides, sending a branch to each side, finally to terminate in the large median gland of the ectal inguinal group (Fig. 4980). According to most authors the urethral and glandular lymphatics of the penis follow the internal pudic blood-vessels into the abdomen and enter the hypogastric glands. But Sappey is very definite, both in his atlas and anatomy, in stating that they enter the large gland, forming the corner of the ectal group.[1]

The external genitalia of the female very closely resemble those of the male in their arrangement and termination. The collecting trunks from the clitoris and the surrounding parts extend nearly directly to the pubis, where they curve to the right and left, and terminate in the large median gland, forming the corner of the ectal inguinal group, and, according to Krause,[6] they also communicate with the lymphatics of the round ligament of the uterus. The lymphatics of the female urethra are less abundant than in the male. The trunks from the urethra, meatus urinarius, labia, and the external or inferior fourth of the vagina extend laterally to reach the vulvo-crural fold, in which they wind around the thigh, with a few small trunks from the perineum to the median of the ectal inguinal glands, only a few reaching the large corner gland to which so many from the male genitalia extend.

The ental lymphatics of the abdominal wall and the lumbar part of the trunk follow the deep blood-vessels; part, therefore, extend to the sternal and axillary glands; part, with the deep epigastric vessels, to the iliac glands; part, with the lumbar and ileo-lumbar vessels, to the lumbar glands. Still others follow the circumflex iliac vessels, often traversing one or more glands along the crest of the ileum before finally entering the iliac glands.

With the dog, cat, and rabbit, the lymphatics of the abdominal wall, and the external genitalia are as in man, except that the tendency to form anastomoses across the meson is more marked, and that there is constantly present along the external epigastric vessels, about opposite the brim of the pelvis, a considerable gland. To this gland pass the ectal abdominal lymphatics, also part of those from the elongated mammary glands and from the external genitalia. There is another gland along the external epigastric blood-vessels about opposite the umbilicus, in the cat at least. After traversing these glands the efferent vessels either join or accompany the femoral lymphatics to the lumbar glands. In the cat they penetrate the abdominal wall with the epigastric artery, and extend, in part, to the hypogastric, and in part to the iliac glands (Fig. 4992, 22, 24). These glands may represent the ectal inguinal glands of man. In the rabbit there is also constantly present a gland on the ilio-lumbar vessels, next the abdominal wall, and along the edge of the sartorius muscle; the efferent vessels pass to the lumbar glands (see 22 of Fig. 4997).

LYMPHATICS OF THE PELVIC AND ABDOMINAL VISCERA.—*Internal genitals of the male—testicle, spermiduct, vesiculæ seminales*, and *prostate*.—Probably no organ in the masculine body is more richly supplied with lymphatics than the testicle. Those of the albuginea are sometimes described as the ectal lymphatics of the testis.

They are only moderately numerous, and extend upon the spermiduct to join those from the testicle proper. Those of the testicle proper follow the seminal tubules to the epididymis, and joining those of the epididymis extend with the spermatic cord through the inguinal canal. After reaching the body cavity they follow the blood-vessels, and finally terminate in the lumbar glands near the end of the spermatic vein.

The lymphatics of the testis of a mature animal are exceedingly easy to inject by the puncture method, and the collecting trunks accompanying the spermatic vein are so prominent, straight, and well supplied with valves that they are among the most striking of the lymphatic trunks in the body.

The lymphatics of the spermiduct are abundant at the

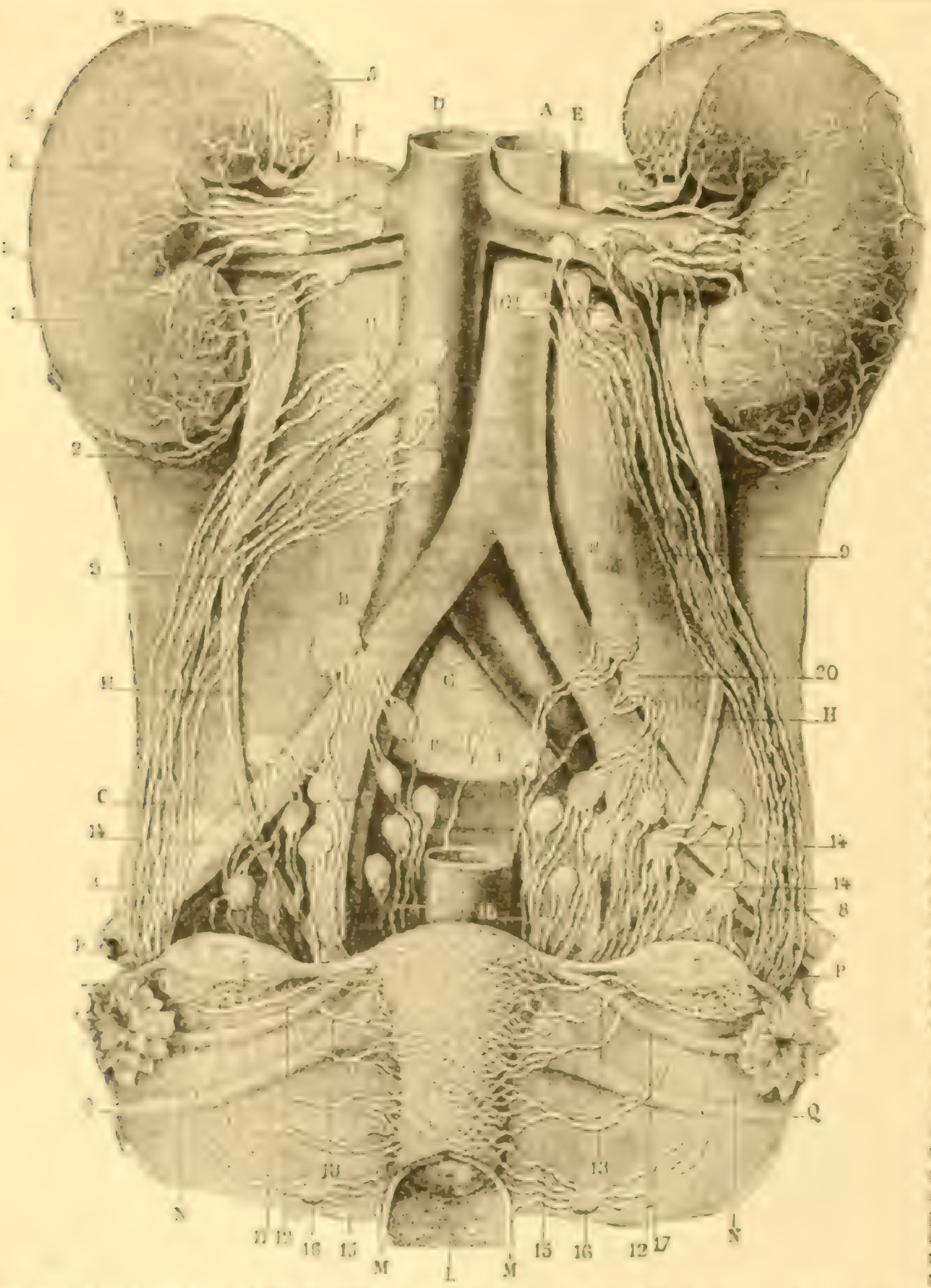


FIG. [illegible].—Lymphatics of the Kidneys, Adrenals, and Internal Genitalia [illegible]

[illegible]

ends, but very few along the middle part. Those from the one half follow the lymphatics of the testis, while those from the other half join the lymphatics of the vesiculæ seminales. The lymphatics of vesiculæ seminales form a plexus which was first described by Henle; they unite into two principal trunks. These meet the spermiduct with the lymphatics of the latter, and together they enter one of the iliac glands. The other trunk passes between the prostate and vesiculæ seminales, so as to join an iliac gland. The lymphatics of the prostate were discovered and described by Sappey in 1854 who found them abundant, and with two collecting trunks on each side. One of the trunks passes quite directly to one of the hypogastric glands, while the other extends upon the walls of the urocyst or urinary bladder, and then curves to the side to enter a hypogastric gland. The trunks extending upon the urocyst were mistaken by Mascagni and Cruikshank for the lymphatics from the bladder itself.

Internal Female Genitalia.—Vagina, Uterus, Fallopian Tubes, and Ovaries.—As described above, the external or inferior fourth of the vagina sends its lymphatics to the [illegible] inguinal glands; from the remaining three-fourths the collecting trunks extend toward the uterus, penetrate the wall of the vagina, and traverse the utero-vaginal lymphatic gland on the way to the hypogastric glands. Up to the present no lymphatics have been demonstrated in the muscular wall of the vagina in the human being, but their presence has been shown in that of the large domestic animals.

The uterine lymphatics are naturally divided into those of the mucosa and those of the muscularis. Those of the mucosa are difficult or impossible to demonstrate in a gravid uterus, and often so in a non-gravid adult uterus, and Sappey states that he never succeeded in demonstrating them in the uterine mucosa of any of the lower animals. It is only in girls before puberty that these lymphatics are demonstrable by the ordinary methods. No doubt they exist in the adult woman, and also in the uterine mucosa of the lower animals, but they have not been satisfactorily demonstrated. When demonstrated in a child they showed a delicate net-work whose collecting trunks traverse the walls of the neck of the uterus and enter the utero-vaginal lymphatic glands (15 and 16, of Fig. 4982). At the os uteri they are continuous with those on the vaginal part of the uterus and the vaginal mucosa.

The lymphatics of the uterine walls are numerous and easily demonstrated in most animals. The collecting trunks extend laterally in the broad ligament on each side to three different groups of glands; those from the summit follow the Fallopian tubes out to the ovary, where they join the ovarian net-work, and accompany the collecting trunks of the ovary to the lumbar glands around the termination of the ovarian veins (Fig. 4982). Those from the body of the organ extend across the broad ligament, curve round the Fallopian tubes, and enter the iliac glands; while those from the cervical region extend with those from the utero-vaginal glands to the hypogastric plexus.

Lymphatics have been demonstrated only on the uterine and ovarian ends of the Fallopian tubes. But it is probable that they are present throughout the whole extent. The collecting trunks accompany the ovarian lymphatics.

The lymphatics of the ovary, like those of the testis, are in prodigious numbers, and are very easily injected. The collecting trunks are very long and straight, and accompany the ovarian vein, and consequently those on the left are opposite the hilus of the kidney (Fig. 4982).

In the lower animals, so far as has been investigated, the lymphatics of the internal genitalia agree in all essential particulars with those of the human being. In the dog, cat, and rabbit, while the ovarian and testicular lymphatics follow the same general course, they almost always enter the lumbar glands, and therefore do not follow the spermatic or ovarian veins to their termination (Fig. 4992). Occasionally one or more branches extend nearly opposite the renal blood-vessels and appear to enter the chylocyst without having traversed any gland. In nearly every case, however, a gland, often exceedingly minute, can be detected in the course of the vessel before its entrance into the chylocyst.

Urinary Organs and Adrenal.—Up to the present time all efforts to demonstrate lymphatics in the mucosa of the urocyst or urinary bladder have failed both with men and with animals, but the muscular coat has been shown to be plentifully supplied. The vessels form a wide-meshed net-work at the summit and on the body. This net-work unites into one or more trunks on each side, and the trunks extend nearly or quite to the neck when they turn aside and enter the hypogastric lymphatic glands. The trunks described by Cruikshank and Mascagni as urocystic lymphatics were really from the prostate. Sappey succeeded only once in injecting them in man, but almost constantly in the dog and rabbit.

The muscularis of the ureters has been shown to possess lymphatics in the horse, but all attempts to demonstrate them in the mucosa has failed. Although not demonstrated in man they are presumably present.

The lymphatics of the kidney form an ectal net-work over the surface and an ental net-work in the substance of the organ. The trunks were first seen in 1532 by Massa, but first described carefully by Nuck in 1590. Those of the surface form a wide-meshed net-work, the collecting-trunks of which extend in part directly toward the hilus of the kidney and join the ental lymphatics, and part extend toward the convex border and then wind round the ends to the hilus. Next the adrenal the lymphatics of the two organs are closely connected. The ental lymphatics follow the blood-vessels and terminate in a group of the lumbar glands situated on the renal vessels.

Although the blood-vessels of the adrenal have been long known the lymphatics were not so early discovered. It is now known that the lymphatics are as abundant as the blood-vessels, extending throughout the substance as well as upon the surface. The collecting trunks, many of them join those of the kidney, and all extend to a gland near the junction of the adrenal and mesal or hilic aspect of the kidney (5, 6, of Fig. 4982).

Lymphatics of the Intestine and Stomach.—Throughout the entire alimentary canal, it has been shown that where a distinct muscular coat exists the lymphatics form two layers or sets, one in the mucosa, including the submucosa, and one in the muscularis. In those parts supported by duplicatures of serosa (mesenteries) the finer net-work of the mucosa proper extends to a coarse and characteristic net-work in the submucosa (Fig. 5009), and finally the collecting trunks penetrate the wall at the attached edge and join the lymphatics of the muscularis. The lymphatics of the muscularis are throughout its entire thickness, but soon become subserous and wind round to the attached edge, and with those from the mucosa extend between the layers of the supporting membrane mostly in company with blood-vessels to lymphatic glands, which are also situated between the serosal walls (Fig. 4983, 19, 22, 24).

The intestinal lymphatics at the anus are directly continuous with those of the skin. The trunks from the muscularis and mucosa of the rectum extend between the folds of the mesorectum, often traversing minute glands in their course, and then enter the sacral lymphatic glands and ultimately go to the lumbar glands on their way to the chylocyst. The lymphatics of the main part of the *colon descendens* pass to the lumbar lymphatic plexus. Those of the *cæcum, colon ascendens et transversum*, also part of the *colon descendens* pass through one or more of the numerous mesocolic glands and then enter the mesenteric glands and mingle with the lacteals from the small intestine, and with these go through the *truncus intestinalis* to the chylocyst.

Lacteals.—The lymphatics of the small intestine are usually called lacteals or chyle vessels, from the fact that during digestion they have a cloudy or milky appearance owing to the contained chyle.

As the small intestine has two planes of lymphatics like the rest of the alimentary canal, it is really only those of the mucosa which absorb and convey the chyle, and which, therefore, should properly be denominated lacteals, as those from the muscularis always convey lymph only. A further and finer distinction still has been made by Sappey,[1] who holds that the vessels of the intestinal villi are the only ones which absorb the chyle, and they do nothing else, so that they alone are the true lacteals, and that the other lymph-vessels of the mucosa and submucosa, including those from the Peyerian patches and other lymphoid tissue, should be considered simply as lymphatics, as they take no part in the absorption of the chyle. The submucosal net-work simply receives the chyle poured into it by the lacteals of the villi. As stated above, this is not the common view. It is ordinarily believed that the lacteals contain lymph like other lymphatics, except during digestion. It is also common to call all the vessels from the small intestine lacteal vessels, without regard to their origin from the muscularis or the mucosa. Whatever the origin, all the vessels unite at the attached border and extend to the nearest gland, where their contents are mixed, so that usually all the collecting trunks in the mesentery appear milky and are called lacteals or chyle-vessels, although some of them might really have come from the large intestine. In man there are usually several tiers of mesenteric glands through which the chyle passes before finally emptying into the large trunk along the superior mesenteric artery. This trunk, which also receives the efferent vessels of the cœliac and mesocolic glands (*truncus lymphaticus intestinalis*), is either single or multiple, and found one of the most important constituents of the [illegible] (Fig. [illegible]).

Stomach.—The lymphatics of the stomach are continuous with those of the œsophagus and duodenum. Those of the mucosa form a most beautiful net-work throughout the entire thickness of the coat; the collecting trunks penetrate the tunics and become subserous, and form an intermediate stratum, with trunks extending to the [illegible] of the chain of lymphatic glands, extending almost around both curvatures; those in the lesser curvature being known as the *glandulæ lymphaticæ gastro-epiploicæ superiores*, and those around the great curvature as the *glandulæ lymphaticæ gastro-epiploicæ inferiores* (Plate XXXIX.). The lymphatics of the gastric mucosa form a remarkable net-work throughout the entire thickness of the coat, being very fine in the mucosa propria and coarser in the submucosa. The collecting vessels penetrate the muscularis along the curvatures, like those of the muscularis, extend to the same glands, and finally to the intestinal lymphatic trunk.

Pancreas.—The lymphatics of this organ are difficult to demonstrate, but when well injected are found to form a fine net-work around the acini (alveoli), and the collecting trunks emerge quite directly to the surface, and form upon the surface a round-meshed, rather coarse net-work, around the lobules. From this net-work trunks extend in three directions—part of them go to the tail or splenic end of the pancreas to join the glands at the hilus of the spleen, part to the [illegible] edge of the pancreas to enter some of the numerous glands along the course of the splenic vessels, and still others extend toward the duodenum to enter a large gland which also receives part of the lymphatics of the duodenum. The lymph finally reaches the intestinal trunk after traversing one or more of the cœliac glands. No lymphatics have yet been demonstrated in the pancreatic ducts.

Spleen.—The lymphatics of the spleen are in enormous numbers. Their origin seems to be from the lymph-follicles so abundant throughout the organ. According to Sappey, the usual division of the lymphatics into a superficial and deep set does not hold good here, where the vessels on the surface quickly enter the substance of the organ and accompany the ental blood-vessels. With the horse, ox, and pig, however, there is a true outer net-work extending over the entire surface. The collecting trunks pass to the hilum of the organ and terminate in the numerous glands there situated. The efferent trunks from these glands pass to the cœliac glands and the intestinal lymphatic trunk, or some may enter the cisterna chyli directly.

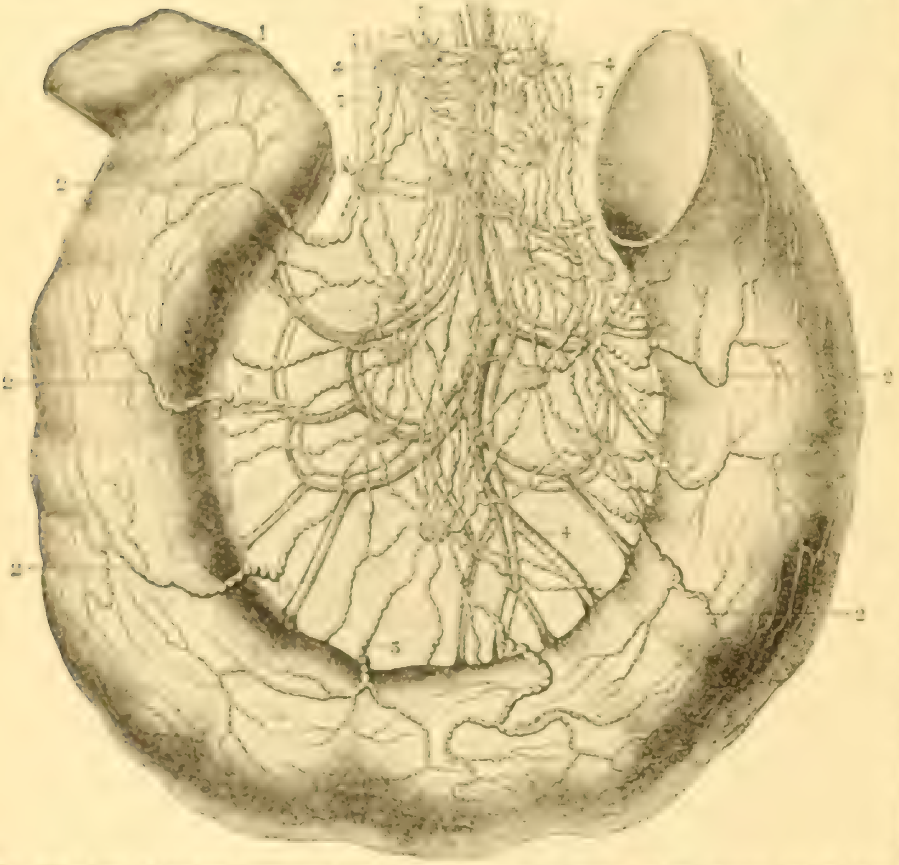


FIG. 4985.—Loop of the Small Intestine of Man, to show the Mesenteric Glands and Blood-vessels and the Lymphatics. [illegible] 1, 1, Two ends of the loop of intestine; 2, 2, 2, 2, 2, lymphatic vessels [illegible]; 3, [illegible]; 4, 4, 4, mesenteric glands [illegible]; [illegible]

Liver.—The lymphatics of the liver were very early seen, and the efferent trunks from the hilus were, for a long time, supposed to be the continuation of the lacteals to the liver. It has been found that the lymphatic system of the liver is quite as remarkable as the blood-supply. In general there are both ectal and ental lymphatic vessels, and the ducts and gall-bladder possess a rich supply. The collecting trunks form three great groups and take three main courses, following the portal vessels to the hilus, the hepatic vessels to the postcava, and the suspensory ligament to the diaphragm.

The ectal or superficial lymphatics of the convex surface extend in four directions according to their position. Most of those near the caudal or inferior border, penetrate the surface and join the ental lymphatics. In the right cephalic (superior) part, they wind round the border and join the glands at the head of the pancreas, or extend to the glands around the postcava as it enters the thorax. On both sides of the suspensory ligament the trunks collect in great numbers, and extend between the folds of the suspensory ligament to the diaphragm, which they penetrate, and enter two or three glands whose efferents join the sternal plexus (14 of Fig. 4986 and 10 of Fig. 4987). Still further to the left, a group pass round to the postcava as it enters the thorax; on the right, still others penetrate the triangular ligament and enter the glands around the œsophagus. Many of the apparently superficial lymphatics of this lobe penetrate the substance of the liver and join the ental lymphatics as with the right lobe. In fact, in most animals this is the normal condition, and a true ectal set of lymphatics is not present.

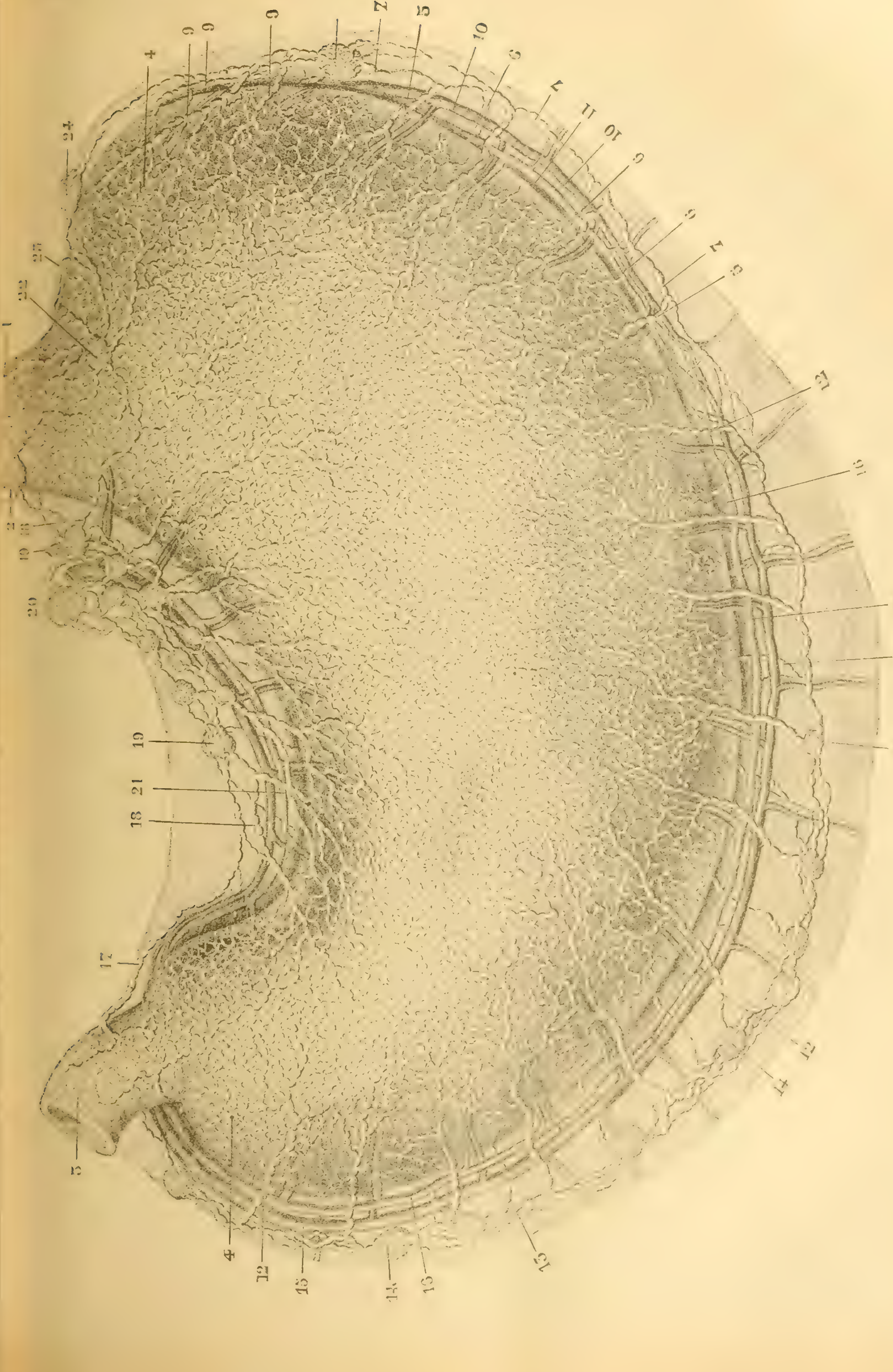
On the concave surface of the liver, many of the surface lymphatics penetrate the liver substance and join the ental lymphatics, but the greater number join the glands in the hilus and then mingle with the ental lymphatics (Fig. 4988). The ental or deep lymphatics, according

EXPLANATION OF PLATE XXXIV.

WHICH REPRESENTS THE LYMPHATICS OF THE HUMAN STOMACH. (SAPPEY, ATLAS.)

1, Gastric end of the oesophagus; 2, lymphatic gland receiving part of the oesophageal lymphatics; its efferent vessels extend to the glands around the coronary blood vessels and there join those from the stomach; 4, 4, fine net-work of vessels in the muscularis of the stomach; 3, the beginning of the duodenum; 4, 4, fine net-work of lymphatic vessels in the muscularis; from this fine net-work arise all the collecting trunks of the muscular coat; 5, 5, 5, lymphatic trunks on the left part of the great curvature; 5.5, 6.6, lymphatic vessels from the dorsal and ventral surfaces of the left third of the great curvature; 7, 7, 7, the principal trunk encircling the left half of the great curvature of the stomach; it receives the branches from the stomach and extends toward the left to enter a large gland (8) situated near the tail of the pancreas and the hilus of the spleen; 8, gland at the left of the stomach near the hilus of the spleen; it receives trunks from both directions, also some from the spleen; 9, trunks from the extreme left of the stomach to the gland marked 8; 10, vena gastro-epiploica sinistra; 11, arteria gastro-epiploica sinistra; 12 and 13, trunks from the dorsal and ventral aspect of the pyloric region; 14, 14, 14, the chain of glands on the right along the great curvature; through these pass all the lymphatics from the half next the greater curvature. The efferent trunks from these glands finally extend to the glands at the head of the pancreas; all the glands in the chain around the great curvature are sometimes designated as the *glandulæ lymphaticæ gastro-epiploicæ inferiores*. They lie in the great omentum and form part of the cœliac lymphatic plexus; 15, 16, vasa gastro-epiploica dextra; 17, trunk from the duodenum and the pylorus to the glands along the lesser curvature; 18, 18, trunks extending to the lesser curvature; 19, 19, the lymphatic glands along the gastric coronary vessels in the lesser curvature (*glandulæ lymphaticæ gastro-epiploicæ superiores*); they receive all the so-called ascending trunks from the stomach and some of the trunks from the oesophagus; they form part of the cœliac lymphatic plexus; 20, the large cœliac gland to which the efferent vessels from 19 extend; 21, vasa coronaria gastrica; 22, gland, often double, on the ventral aspect of the cardia; 23, large trunk winding round the cardia and joining the trunk to 22 and 24; 24, gland, sometimes visible, at the extreme left of the great curvature.

PLATE XXXIV.



LYMPHATICS OF THE HUMAN STOMACH.

SAPPEY ATLAS

to Sappey, are divided into two distinct, although anastomosing sets, one set following the portal vessels and bile-ducts, the other the hepatic vessels. Those following the hepatic vessels enter the thorax, traversing some glands on the postcava, and mingling with the ectal lymphatics, follow the pillars of the diaphragm to join the thoracic duct. The lymphatics following the portal veins reach the hilus of the liver, and traverse one or more of the glands there situated (Fig. 4984). From these glands in the hilus, branches extend to the glands in the lesser curvature of the stomach, and to those on the splenic vessels; but finally all pass to the cœliac glands, and then some branches may enter the chylocyst independently, but most of them join the intestinal trunk.

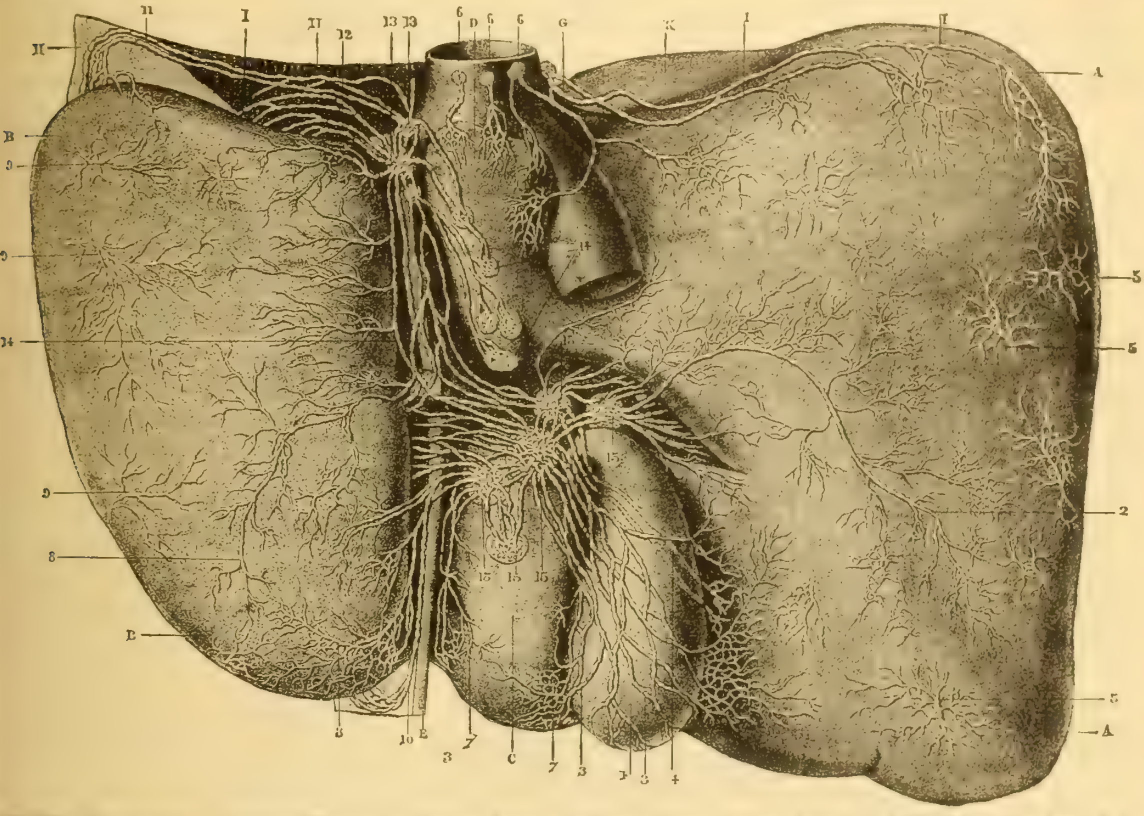


Fig. 4984.—Lymphatics and Lymphatic Glands on the Concave Aspect of the Liver of Man. (Sappey, Atlas.) A, A, Right lobe of the liver; B, B, left lobe; C, quadrate lobe; D, Spigelian lobe; E, round ligament or remnant of umbilical vein; F, cholecyst or gall bladder; G, postcava receiving the hepatic veins just as it traverses the diaphragm; H, left triangular ligament of the liver; I, diaphragm; K, the most projecting part of the convex surface of the liver.

1, 1, Two trunks near the cephalic edge of the right lobe extending to the glands on the postcava just within the thorax; 2, single trunk from the middle of the right lobe to the lymphatic glands in the hilus of the liver by the neck of the cholecyst; 3, 3, trunks upon and at the border of the cholecyst to the glands in the hilus; 4, two vessels having the same origin and termination, but covered by the cholecyst: their course is indicated by the dotted lines; 5, 5, trunks arising on the surface of the right lobe, but penetrating the substance of the liver to accompany the ental vessels; all the vessels from the surface take this course in most animals; 6, 6, 6, trunks from the Spigelian lobe, and the glands around the postcava receiving them; 7, 7, vessels belonging to the quadrate lobe; 8, 8, principal trunks of the left lobe; 9, 9, vessels arising on the surface, but soon entering the liver to join the deep lymphatics like 5 of the right lobe; 10, trunks from the convex surface of the liver following the round ligament and finally entering the glands at the hilus; 11, 11, 12, several trunks from the convex surface of the left lobe, winding over to the concave surface and entering glands in the fissure of the ductus venosus; 13, 13, lymphatic glands in the fissure of the ductus venosus, their efferent vessels extend to the glands in the hilus; 14, glands corresponding to the terminal end of the œsophagus; 15, 15, lymphatic glands receiving the lymphatics from most of the concave surface of the liver and the ental lymphatics following the portal vein.

Lymphatic Glands, Plexuses, and Trunks of the Abdominal and Pelvic Cavities.—The glands in the abdominal and pelvic cavities form a continuous net-work from the inguinal glands to those in the œsophageal opening; they also extend out on the great vessels of the viscera. Although there are no sharply defined limits and limited grouping of the 200 to 400 glands in this part of the body, groups have been made as in the neck for convenience. Following Krause, the following groups may be recognized, commencing with the iliac region: (1) Iliac; (2) hypogastric; (3) sacral; (4) lumbar; (5) mesenteric, including those of the meso-colon; (6) cœliac. Each of these groups of glands with the connecting vessels is also called a plexus. As the efferent vessels of all these groups unite to form the *chylocyst* and thoracic duct by three main trunks, these also have received names: (1) The two lumbar trunks (a *truncus lymphaticus lumbalis* of each side) from the iliac, hypogastric, sacral, and lumbar plexuses, and (2) a single trunk (*truncus lymphaticus intestinalis*) from the mesenteric and cœliac lymphatic plexuses. As was remarked in discussing the cervical glands, different authors may assign a collecting trunk from an organ to different groups of glands, although the same gland is meant. As the division into groups is artificial, and the glands vary considerably in position and in different individuals, even in number, this confusion is probably inevitable.

The iliac lymphatic glands and plexus (*glandulæ iliacæ, s. iliacæ externæ, s. anteriores; plexus lymphaticus iliacus, s. iliacus externus, s. anterior*) form a chain along the external and common iliac blood-vessels. At the crural ring this plexus is continuous with the inguinal plexus. The afferent vessels are from the inguinal plexus, those accompanying the internal epigastric and circumflex iliac blood-vessels, those from the vesiculæ seminales and the body of the uterus (those from the last two sources are often said to extend to the hypogastric plexus). This plexus is connected with the hypogastric and sacral by several communicating branches, but the main efferent trunks pass to the lumbar plexus.

Hypogastric Glands and Plexus (*glandulæ lymphaticæ hypogastricæ s. iliacæ internæ s. pelvinæ; plexus hypogastricus s. iliacus internus s. pelvinus*). These are on the sides of the pelvis around the hypogastric and internal iliac blood-vessels. The afferent lymphatics are from the gluteal, sciatic, and obturator vessels, part of the perineum, the prostate, urethra, most of the vagina, the [illegible], and neck of the uterus. According to most authors the ental lymphatics of the external genitalia in both sexes pass to these glands. Sometimes also part of the inguinal efferents pass to this group. This plexus is closely connected with the iliac and sacral, but its principal efferent trunks pass to the lumbar plexus.

Sacral Glands and Plexus (*glandulæ lymphaticæ sacrales; plexus lymphaticus sacralis*). This group of glands is between the folds of the mesorectum next the sacrum. The afferent vessels come from a part of the pelvic wall and the vertebral canal, also from the rectum. Like the other pelvic plexuses it is connected with all the others, but its efferent trunks pass to the lumbar plexus.

The Lumbar Glands and Plexus (*glandulæ lymphaticæ lumbales s. lumbares; plexus lymphaticus lumbalis*). The lumbar glands form three irregular rows, one mesal and two lateral, extending along the great blood-vessels from the bifurcation of the aorta nearly to the origin of the superior mesenteric artery. Its afferent vessels are the efferent trunks from the iliac, hypogastric, and sacral plexuses, lymphatics accompanying the ilio-lumbar and part of the lumbar blood-vessels, those from the testis, spermatic cord or parovarium, ovary, summit of uterus, Fallopian tubes, kidney, adrenal, and some of the colon descendens. It is also connected by a greater or less number of communicating branches with the cœliac plexus. Its efferent vessels unite to form two principal trunks, a right and left lumbar lymphatic trunk (*truncus lymphaticus lumbalis*), which with the intestinal trunk form the *chylocyst*, the enlarged beginning of the thoracic duct.

Cœliac Glands and Plexus (*glandulæ lymphaticæ cœliacæ; plexus lymphaticus cœliacus*). The cœliac plexus is situated along the cœliac vessels, the portal vein and the beginning of the superior mesenteric artery on the dorsal side of the pancreas, duodenum, and pylorus. This group was formerly described as part of the lumbar plexus. The afferent lymphatics come from the stomach, part of the œsophagus and duodenum, part of the liver, the pancreas and spleen. The efferent vessels join the intestinal trunk, or sometimes one or more branches pass directly to the chylocyst.

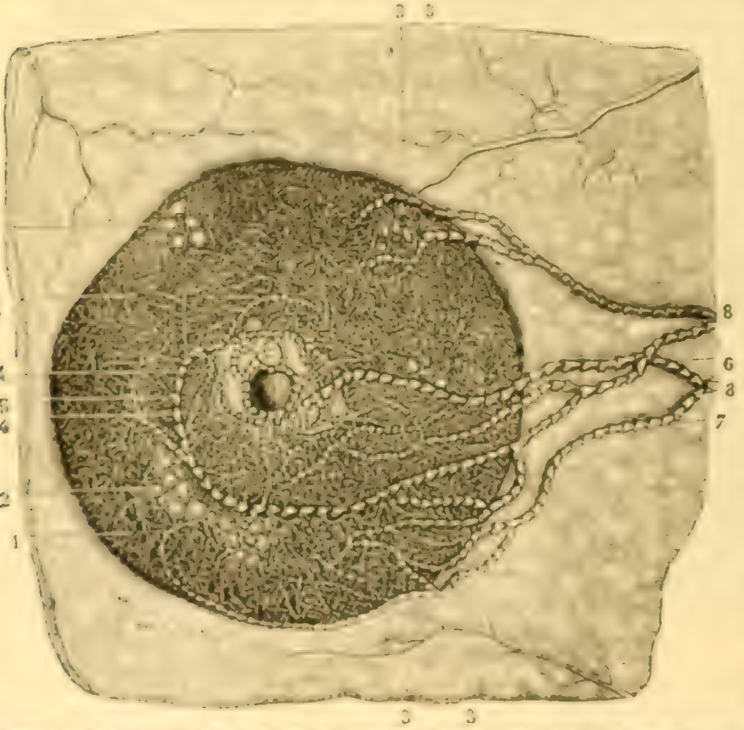


FIG. [illegible].—Left Mammary Gland of a Woman during Lactation. The skin and adipose tissue have been removed to bring the lymphatic plexus into view. At three of the corners of the figure blood-vessels are represented. (Sappey: [illegible].) 1, 1, Network of lymphatics [illegible]; 2, 2, [illegible]; 3, 3, large trunks at the corners of the gland; 4, 4, [illegible] of large vessels around the nipple; they originate in the depth of the [illegible]; 5, 5, great trunk arising at the mesial side of the nipple, and extending across the [illegible] to the axillary lymphatic glands; 6, large trunk from the [illegible] of the nipple extending directly toward the axilla; 7, large trunk from the [illegible] of the mamma, and uniting with the preceding on its way to the axilla; 8, 8, the two great trunks from the mammary gland going to terminate in the axillary lymphatic glands.

Mesenteric Glands and Plexus (*glandulæ mesentericæ s. mesaraicæ; plexus lymphaticus mesentericus s. mesaraicus*). The mesenteric glands and plexus (100 to 200) lie along the blood-vessels between the folds of the mesentery and the mesocolon. They are usually in three irregular tiers, one tier being near the intestine, one near the middle, and one near the root of the mesentery. The afferent vessels are from the small intestine except part of the duodenum, and the large intestine to the sigmoid flexure. The efferent vessels receive the efferent trunks from the cœliac plexus and then terminate in the chylocyst as the intestinal trunk (*truncus lymphaticus intestinalis*).

As will be seen by a glance at Figs. 4992, 4995, and 4997, the lymphatics and the glands in the abdominal cavity of the dog, cat, and rabbit, are essentially as in man, but there is a greater concentration of the glands, so that the groups are well defined. No sacral glands were certainly found in any of them.*

LYMPHATICS OF THE THORAX.—The thoracic lymphatics are divisible into three fairly distinct, although communicating, groups: (1) Those of the skin and other surface structures; (2) the ental lymphatics of the thoracic walls, including the diaphragm; (3) the lymphatics of the thoracic viscera—heart, lungs, trachea, and œsophagus.

The ectal lymphatics, like those of the abdomen, are quite sharply divided into those of the right and those of the left side, although on both the dorsi- and ventri-meson the vessels intercommunicate.

The beginning of many of the subcutaneous trunks of the thorax is likewise from an oblique zone surrounding the body at about the level of the umbilicus (Fig. 4986), and there is a somewhat similar, although less clearly defined, limiting zone between the neck and thorax. The collecting trunks extend in the most direct manner to the axillary lymphatic glands (Fig. 4989). Part of those, however, in the subclavicular and adjoining pectoral regions pass to the supraclavicular glands. This is supposed to explain the involvement of these glands in some cases of cancer of the breast.

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* Sappey describes and figures in his Atlas (Plate XXVIII., Fig. [illegible]) the lumbar trunks [illegible] [illegible]. Such a condition was never observed by the writer in any of the white rabbits dissected.

Belonging to this ectal group are the lymphatics of the mammary gland. In the male they are but little more developed than the surrounding integument; but in the female, especially in preparation for and during lactation, they are present in enormous numbers, and their size is also greatly increased. Those of the mammary integument are especially numerous in the areola, but it is in the glandular substance itself that they reach their highest development. From the substance of the gland they reach the surface in four places, and extend as four principal trunks toward the axilla, but most often unite to form two large trunks before entering the axillary glands. Most authors assign part of the lymphatics of the breast to the internal mammary or sternal plexus, but Sappey states that the course is as described above.

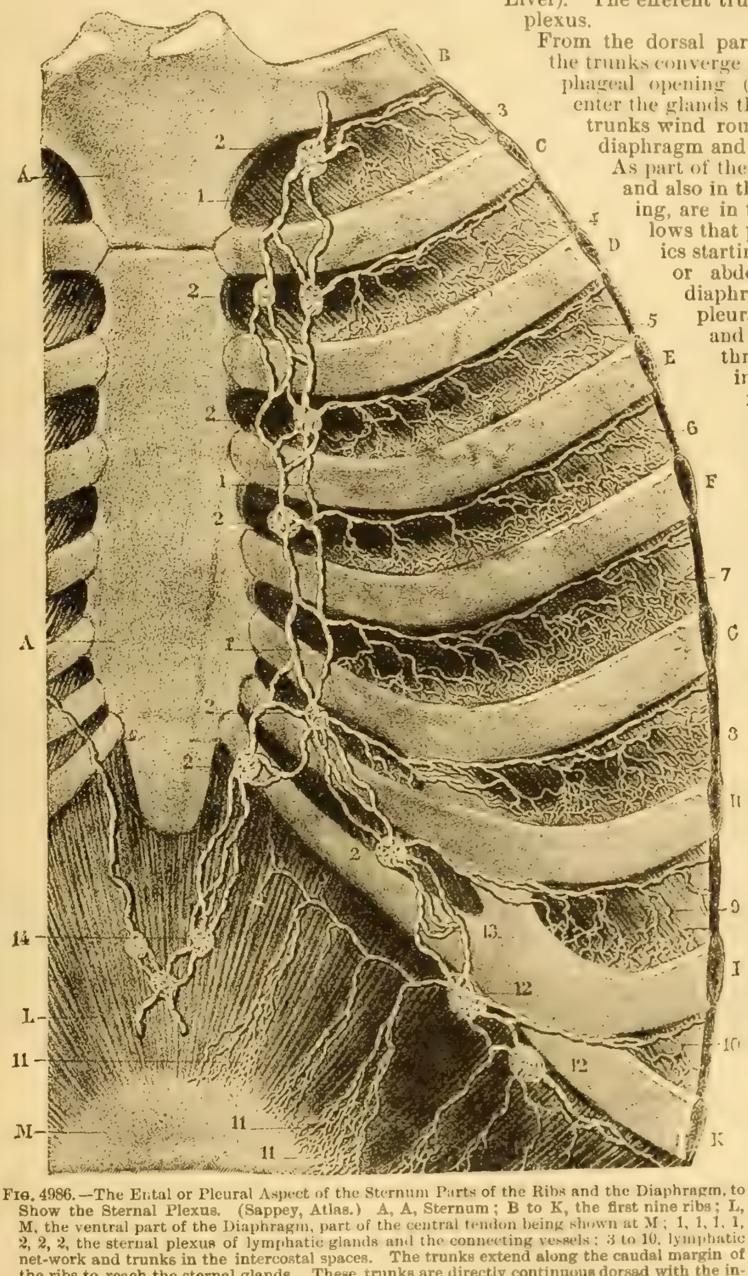


Fig. 4986.—The Ental or Pleural Aspect of the Sternum Parts of the Ribs and the Diaphragm, to Show the Sternal Plexus. (Sappey, Atlas.) A, A, Sternum; B to K, the first nine ribs; L, M, the ventral part of the Diaphragm, part of the central tendon being shown at M; 1, 1, 1, 1, 2, 2, 2, the sternal plexus of lymphatic glands and the connecting vessels; 3 to 10, lymphatic net-work and trunks in the intercostal spaces. The trunks extend along the caudal margin of the ribs to reach the sternal glands. These trunks are directly continuous dorsad with the intercostal plexus (cf. Fig. 4991); 11, 11, vessels on the pleural surface of the diaphragm, finally extending to the sternal glands; 12, 12, 13, sternal glands opposite the eighth and ninth ribs and their efferent trunks; 14, glands receiving the lymphatics from the suspensory ligament of the liver.

Besides the lymphatics from the mammary glands, many of those from the ectal muscles pass to the axillary glands. These trunks pass along the great pectoral muscles and the vasa thoracica longa, and usually traverse a few small glands (pectoral glands) in their course.

The lymphatics of the diaphragm were discovered by Rudbeck, and fully described by Nuck. They are among the most easily demonstrated of any in the body, and from the thinness of the diaphragm and the clearness with which the lymphatics may be followed, this organ is a favorite object for study. The lymphatics extend from the peritoneal to the pleural surface, hence it is upon the thoracic face that the great trunks are found (Fig. 4987). These are arranged into three paired and one azygos group. The lymphatic trunks of the diaphragm practically surround the whole organ and the openings through it. From the ventral group, occupying somewhat more than the ventral half, the trunks extend toward the sternum, traverse a gland about opposite the seventh rib, and then extend to the sternal plexus, those of the right going to the right lymphatic trunk, and those of the left going to the thoracic duct (Fig. 4987). The azygos group appears opposite the xiphisternum, and is represented by three glands (supra-xiphoid of Sappey, anterior mediastinal of authors), and their efferent trunks. These are not properly diaphragmatic lymphatics, for they come from the surface of the liver and suspensory ligament (see Liver). The efferent trunks join the sternal plexus.

From the dorsal part of the diaphragm the trunks converge to the aortic or œsophageal opening (dorsal group), and enter the glands there situated. Other trunks wind round the pillars of the diaphragm and enter the abdomen. As part of the glands in the aortic, and also in the œsophageal opening, are in the abdomen, it follows that part of the lymphatics starting on the peritoneal or abdominal side of the diaphragm extend to the pleural or thoracic side, and then turn back through these trunks into the abdomen before finally terminating in the thoracic duct. Everything seems to be complex in anatomy.

The deep structures of the thoracic walls are drained by lymphatics following the intercostal spaces. As will be seen by consulting Figs. 4986 and 4991, the collecting trunks form a half-circle, the vessels extending both toward the sternal and toward the intercostal plexus. In their course along the intercostal spaces they usually traverse one or more glands. Near the spinal column is a row of glands whose efferent trunks may extend directly to the thoracic duct, but usually two or three of them unite to form a common trunk, which opens into the thoracic duct. It is a remarkable fact, that those from the last three intercostal spaces unite to form trunks on each side, which extend through the diaphragm into the abdomen to join the chylocyst, instead of entering the thoracic duct in the thorax (cf. Fig. 4993, where vessels pass from the abdomen to the thorax).

From the first few intercostal spaces the collecting trunks on the right side pass to the right lymphatic trunk; and from the sternal half of all of the spaces the collecting trunks join the sternal plexus, those on the right extending therefrom to the right lymphatic trunk, and those on the left to the thoracic duct. This offers a very striking illustration of the close connection between the right and left lymphatic trunks in man, a condition much more fully realized in many of the lower animals, as marsupials, birds, reptiles, amphibians, and fishes. The lymphatics of the spinal canal and the muscles of the back follow their blood-vessels and enter the intercostal plexus, the greater number finally reaching the thoracic duct.

Œsophagus.—The lymphatics of the œsophagus form two sets, like the rest of the alimentary canal, viz., those of the muscularis and those of the mucosa; they penetrate the muscular wall and enter the small glands scattered along its course. The lymphatics are directly continuous with those of the pharynx at one end and with those of the stomach at the other. At the gastric end the collecting trunks, after reaching the surface, extend toward the stomach, and part of them traverse the œsophageal open-

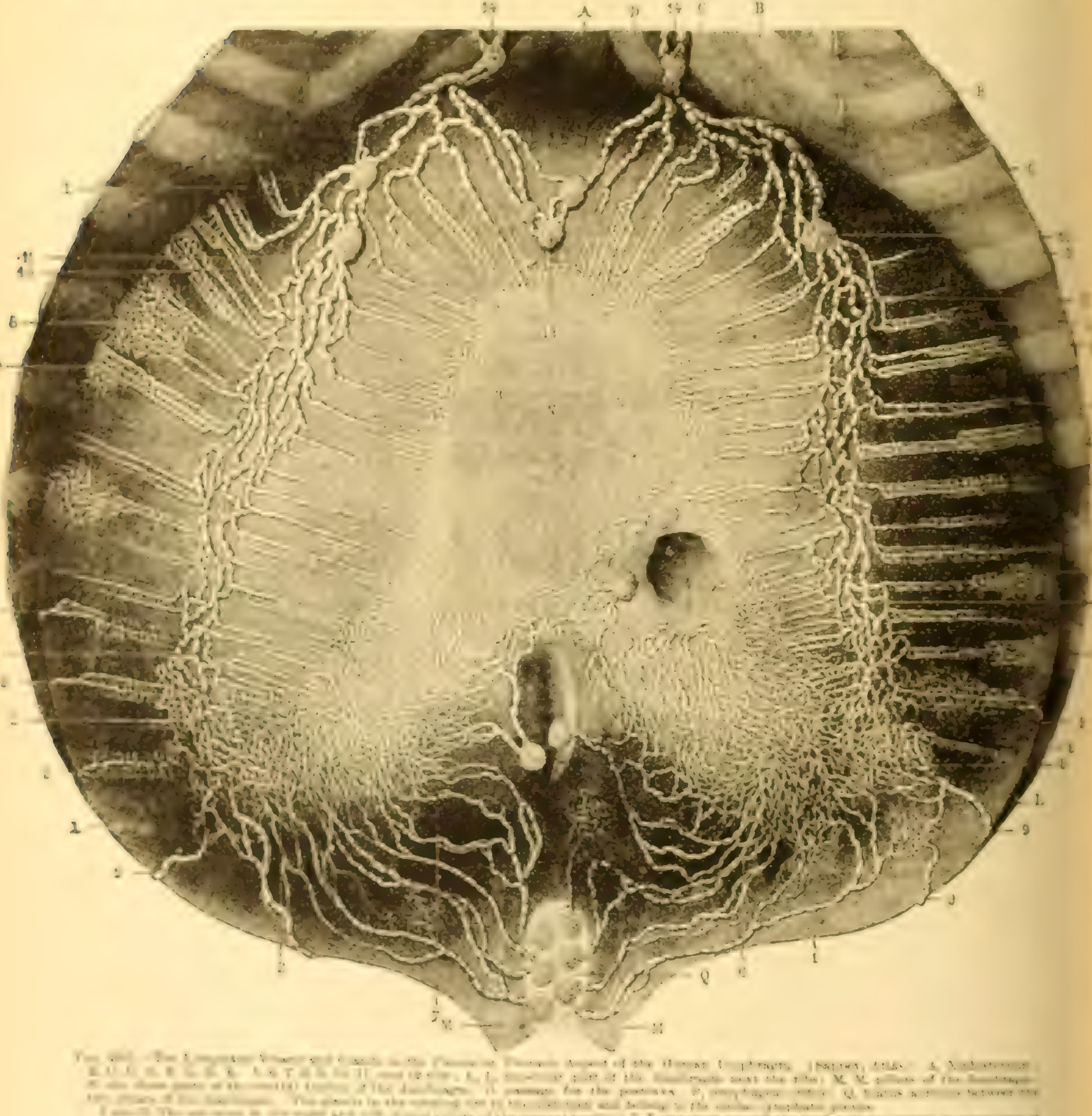


FIG. [illegible].—The Lymphatic Vessels and Glands in the [illegible] Aspect of the Human Diaphragm. (Sappey, [illegible].) [illegible] M, M, pillars of the diaphragm; [illegible] Q, hiatus [illegible] between the two pillars of the diaphragm. [illegible] Fig. [illegible].

ing and enter the glands around the cardia of the stomach (Plate XXXIV.). Those of the middle region enter the dorsal (posterior) mediastinal glands, while those in the neck join the internal jugular plexus. Up to the present time the lymphatics of the muscularis have been actually demonstrated only in the larger domestic animals (horse and ox), but the probability that they exist in the human œsophageal muscularis is very strong.

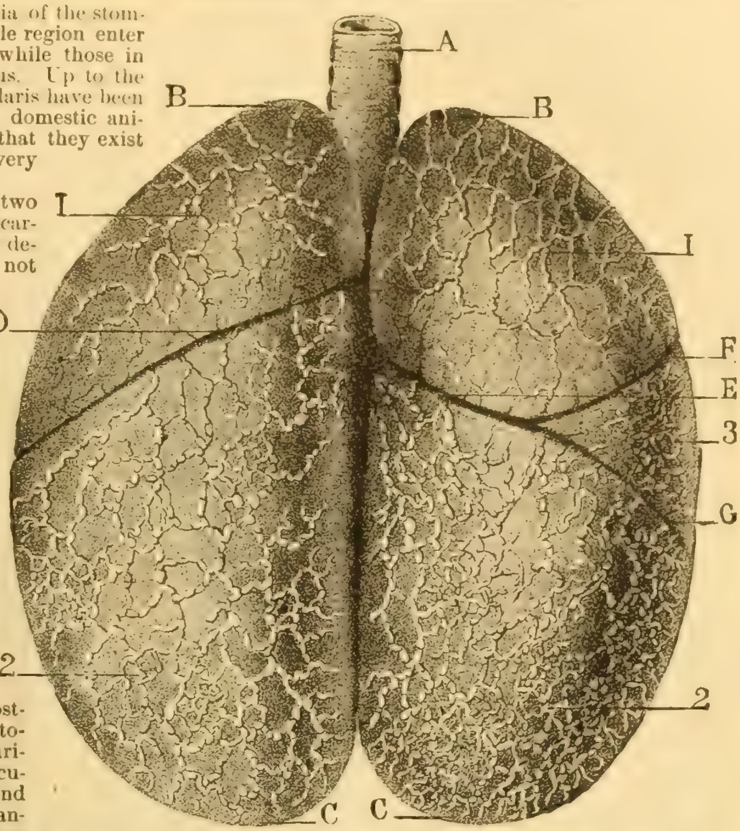


Fig. 4989.—Ectal or Subserous Lymphatics of the Dorsal Surface of the Lungs of a Child at Birth. (Sappey, Atlas.) A, trachea—the line points to the membranous portion; B, B, summit or cephalic lobes of the two lungs; D, the fissure dividing the left lung into two lobes; E, F, G, fissures dividing the right lung into three lobes.
1, Lymphatic net-work on the cephalic lobe; 2, 2, net-work on the caudal lobe; net-work on the middle lobe of the right lung. The fine net-work surrounding and covering the pulmonary lobules is not shown in this figure.

Heart.—The cardiac lymphatics are in two groups—a sub-pericardial and a sub-endocardial net-work—but in both cases they are derived from the muscular substance, and not from the serosa. The ectal or sub-pericardial net-work commences with the apex of the heart and extends over the whole surface, but the larger trunks occupy the dorsal and ventral grooves or depressions containing the large cardiac blood-vessels. The ental or subendocardial vessels unite into collecting trunks which penetrate the myocardium near the apex and near the auriculo-ventricular groove, and anastomose with the ectal lymphatics, and all together extend to the groove between the auricles and ventricles, and form an anastomosing circle around the base of the ventricles. The rather few lymphatics of the auricles mostly extend toward the auriculo-ventricular groove and join the anastomosing ring, but some extend directly to the main trunks along the two sides of the pulmonary artery. From the anastomosing ring in the auriculo-ventricular groove two trunks arise, the one representing the left heart extends along the left side of the pulmonary artery, and between it and the left auricle to the left bronchial glands, and therefore finally to the thoracic duct. The trunk representing the right heart follows the right side of the pulmonary artery, and passes between this vessel and the arch of the aorta to reach the right bronchial glands, ultimately to terminate in the right common lymphatic trunk.

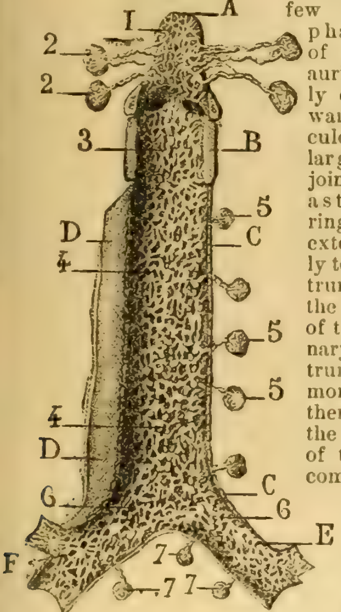


Fig. 4988.—Trachea and Bronchi Opened on the Dorsal Side to Show the Abundant Lymphatic Net-work of the Mucosa: from a Child at Birth. (Sappey, Atlas.) A, Epiglottis; B, section of the cricoid cartilage to expose the interior of the larynx; C, C, trachea; D, D, the membranous portion of the trachea drawn to the left, exposing the interior; E and F, the two bronchi.
1, The lymphatic net-work of the epiglottis: 2, 2, ental cervical lymphatic glands (cf. Plate XXXIII., 13); subglottic net-work in the larynx: this is very sparing in the adult: 4, 4, net-work of the tracheal mucosa; 5, 5, ental cervical glands along the trachea into which the collecting trunks enter; 6, 6, the lymphatic net-work in the bronchi; it will be seen from this figure that the lymphatic net-work from the epiglottis into the bronchi is uninterruptedly dense; in the adult there are comparatively few lymphatics in the larynx proper and in the trachea; 7, 7, bronchial lymphatic glands.

Lungs.—The lymphatics of the lungs are exceedingly numerous. They arise in the lung substance between the alveoli, and in the bronchial mucosa. Those near the surface extend toward the periphery and become subserous, and then extend to the root of the lung to enter the bronchial glands (Figs. 4988 and 4989). The ental lymphatics follow the bronchi and finally, after traversing a few small glands on the bronchi (the so-called pulmonary lymphatic glands), they enter the bronchial glands. From these glands extend trunks to the left to enter the thoracic duct, and to the right to enter the right common lymphatic trunk.

Trachea and Bronchi.—As seen above, the epiglottis and entire laryngeal opening possess an almost infinite number of lymphatics (Pl. XXXIII.). In the infant this wealth of vessels continues throughout the entire larynx, and trachea and its branches; but as age advances the lymphatics of the larynx, commencing at the level of the vocal cords, and the trachea become less and less, until in the adult they are comparatively few; but in the smaller bronchi the abundant lymphatic net-work persists. The vessels arise in the mucosa and the intercartilaginous tissue, penetrate the tracheal wall, and are distributed to the glands so abundantly supplied to the neck along the trachea and bronchi (Fig. 4988).

THORACIC LYMPHATIC GLANDS.—The lymphatic glands of the thorax are only second in importance and number to those in the abdomen. Within the thorax they form a continuous net-work, and are closely connected with those of the abdomen on the one hand, and with those of the neck on the other. Those without the cavity are continuous with the axillary glands.

The pectoral glands (*glandulæ lymphaticæ pectorales, s. thoracicæ superficiales*) are situated along the caudal (inferior) border of the great pectoral muscle, and some more deeply along the vasa thoracica longa. Through them pass many of the trunks following the long thoracic blood-vessels, and many of those from the thoracic region on their way to the axillary lymphatic glands.

Within the thorax there are several named groups with corresponding plexuses. The sternal glands and plexus (*glandulæ lymphaticæ sternales s. substernales, s. thoracicæ profundæ s. internæ s. parasternales; plexus lymphaticus sternalis s. mammarius internus*) commence opposite the xiphisternum and extend along the thorax on each side of the sternum in company with the sternal blood-vessels (Fig. 4999). The afferent vessels of this plexus come from the deep abdominal muscles in the supra-umbilical region of the abdomen, the ventral two-thirds of the diaphragm, part of the convex surface of the liver through the supra-xiphoid glands, the structures in the intercostal spaces in the ventral part of the body. The efferent vessels usually join the ventral (anterior) mediastinal glands, and with their trunks pass to the two great common lymph-trunks. Sometimes one or more, or all, of the trunks pass directly to the great lymph-trunks without traversing the mediastinal glands.

The intercostal glands and plexus (*glandulæ lymphaticæ intercostales; plexus lymphaticus intercostalis*) are found on each side of the thorax in the intercostal spaces and along the vertebral column. The afferent vessels are from the intercostal structures, the spinal canal, and the deep muscles of the back. The efferent trunks pass mostly to the thoracic duct, but part of those on the right pass to the right lymphatic trunk.

The dorsal or posterior mediastinal glands and plexus (*glandulæ lymphaticæ mediastinales dorsales, s. posteriores; plexus lymphaticus mediastinalis dorsalis s. posterior*) are situated along the thoracic aorta and the œsophagus in the dorsal or posterior mediastinal folds. The afferent vessels are from the œsophagus, the dorsal third of the diaphragm, and some from the liver. The efferent vessels enter the thoracic duct directly or join the bronchial glands.

The ventral (anterior) mediastinal glands and plexus (*glandulæ lymphaticæ mediastinales ventrales s. anteriores, s. gl. l. cardiacæ; plexus lymphaticus mediastinalis ventralis s. anterior*) are in the ventral mediastinal fold, and are principally concentrated around the arch of the aorta and the roots of the great blood vessels. The glands called supra-xiphoid by Sappey (14 of Fig. 4986) are frequently assigned to this group. The afferent vessels are from the sternal plexus, and through this many vessels from the convex surface of the liver; the lymphatics of the thymus, and, according to some authors, the lymphatics of the heart. The efferent vessels either go to the bronchial glands or join the vessels from these, and extend from the right half to the right lymphatic trunk, and from the left half to the thoracic duct.

The bronchial glands and plexus (*glandulæ lymphaticæ bronchiales; plexus lymphaticus bronchialis*) are situated in the bifurcation of the trachea, and extend upon the trachea (where they are called tracheal lymphatic glands) to the internal jugular plexus, and others extend out along the bronchi into the lungs (pulmonary lymphatic glands). In childhood and youth they are pink, but with advancing age they become dark and even black, if the individual has inhaled a plentiful supply of coal-dust or other carbonaceous matter. These glands are very large and important. The afferent vessels are from the lungs, and, according to some authors, the heart, the bronchi, the efferent vessels of the dorsal mediastinal glands, and sometimes the ventral mediastinal glands also. The efferent vessels extend from the left side to the thoracic duct, and from the right to the right lymphatic trunk. Frequently the efferent vessels of the sternal, ventral mediastinal, and bronchial glands unite to form a large single or multiple trunk (*truncus lymphaticus broncho-mediastinalis, s. lymph-mediastinus, s. broncho-mediastinus*), which extends to the common lymphatic trunk of the right or left. Such a trunk is more common on the right. On the left the efferent trunks are usually smaller and less concentrated.

COMMON LYMPHATIC TRUNKS.—In man and the mammals there are but two common lymphatic trunks, one on the right and one on the left side; and these trunks terminate at two points in the great veins of the neck, usually at the junction of the jugular and subclavian veins—that is, just before the formation of the brachio-cephalic venous trunks, or in animals like the rabbit (Fig. 4998) with a right and left precava, just before the formation of these. In man and the higher animals these trunks are of different length and size, and receive the lymphatics of very unequal portions of the body, that on the left side being naturally much the more extensive. In the lowest mammals the tendency is very strong to equalize these trunks and also the area drained by them; and in the animals below mammals, the two are approximately equal.

Thoracic Duct (*ductus thoracicus s. truncus s. canalis lymphaticus communis sinister, s. major, s. ductus chyliferus s. Eustachianus*; named after Bartolommeo [Eustachius, 1564]).—The common lymphatic duct, canal, or trunk of the left side collects and empties into the venous system, the lymph of the pelvic limbs, the reproductive and urinary organs, the alimentary canal, pancreas, spleen, much of that of the liver, of the left half of the body cephalad of (above) the umbilicus with the addition of a part from the right half of the thoracic wall (Figs. 4989 and 4990 to 4998).

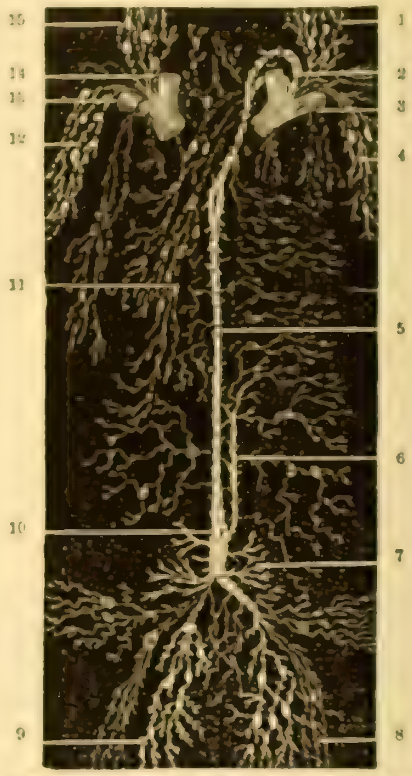


FIG. 4990.—Diagram of the Thoracic Duct, the Right Lymphatic Trunk, and the Lymphatic Plexuses of the Human Body. (After Quain.) 1, left jugular plexus; 2, arch of the thoracic duct near its entrance into the angle between the subclavian and internal jugular veins; 3, left subclavian vein; 4, left axillary lymphatic plexus; 5, the thoracic duct in the thorax; 6, trunk from the intercostal plexus to the duct, where it joins the [illegible]; there should be a similar trunk on the left (cf. Fig. 4991); 7, cisterna; 8 and 9, inguinal and iliac plexuses of the left and right; 10, [illegible]; 11, the sternal, bronchial, and mediastinal plexuses; 12, axillary plexus of the right; 13 and 14, right subclavian and internal jugular veins; the right lymphatic trunk enters the vein at the angle between the subclavian and internal jugular as does the thoracic duct on the left; 15, right jugular lymphatic plexus.

In man the thoracic duct is formed in the abdomen opposite the first, second, or third lumbar vertebra by the union of the trunks of the lumbar and mesenteric lymphatic plexuses. The most caudal end is the result of the union of the right and left lumbar trunk (*truncus lymphaticus lumbalis dexter et sinister*). The large trunk thus formed is then increased by the addition of the unpaired or azygous trunk (*truncus intestinalis*) from the stomach and intestines, part of the liver, the spleen and pancreas, and the right and left trunk from the intercostal plexuses (Fig. 4990). At the beginning of the duct where all these confluents unite there is usually a marked dilatation, the chylocyst, chyle receptacle or cistern of Pecquet (*chylocystis, s. receptaculum chyli, s. cisterna chyli*). This is sometimes absent in man as the confluents form a kind of net-work instead of one large trunk. In this case the thoracic duct is formed by the union of the net-work without there being present a special enlargement or chylocyst. This condition is said by Owen to be normal in the marsupials examined by him, but in the dog, cat, rabbit, and most of the higher animals there is usually a very well-marked chylocyst. From the chylocyst the thoracic duct traverses the diaphragm with the aorta, usually on the right side, and extends along the thorax mostly on the right and dorsal side of the aorta until opposite the sixth to the third thoracic vertebra it gradually inclines to the left, passes dorsad of the arch of the aorta, reaches the left side of the œsophagus which it follows for a short distance, passing on with it along the dorsal side of the great blood-vessels until opposite the seventh cervical vertebra when it forms an arch something like the arch of the aorta, curving ventrad and to the left between the vertebral blood-vessels and the jugular vein to terminate at the junction of the left internal jugular and the subclavian vein. The opening is guarded by a double valve, so that reversal of the direction of the stream is avoided.

The thoracic duct differs in length with the length of the trunk. The average in an adult is about 40 ctm., and its diameter is about 2 to 3 mm., it being greater near its origin than near its termination. It in many cases divides into two or more parallel and anastomosing vessels, which finally unite to enter the vein together. The chylocyst is from 40 to 50 mm. long and 6 to 8 mm. thick, and in the arch near the termination there is sometimes, if not regularly, found a dilatation something like that shown in the dog and the rabbit (Figs. 4996 and 4998). The thoracic duct receives confluent branches throughout its entire course, and near the termination enter the important trunks from the arm, lungs, and head and neck (the jugular, subclavian, and broncho mediastinal trunks). The entrance of each of these vessels is usually guarded by a paired valve.

Varieties.—There are sometimes two ducts—one opening into the right, and one into the left veins of the neck. Sometimes a single duct divides, sending one branch to the right and one to the left, as shown in the figure of the cat and rabbit (Figs. 4993 and 4998). Rarely there is a transposition, the left thoracic duct opening on the right. "In two instances the thoracic duct has been seen to terminate in the vena azygos." Multiple openings into the veins are not uncommon (cf. Fig. 4994).

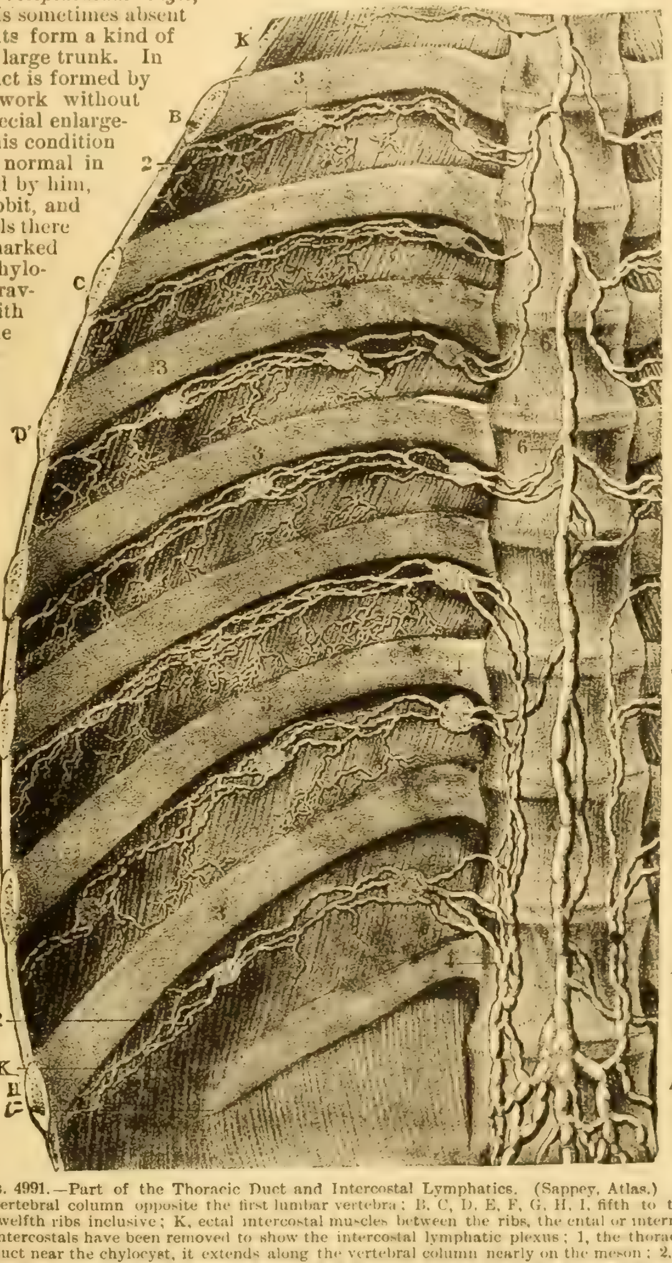


Fig. 4991.—Part of the Thoracic Duct and Intercostal Lymphatics. (Sappey, Atlas.) A, vertebral column opposite the first lumbar vertebra; B, C, D, E, F, G, H, I, fifth to the twelfth ribs inclusive; K, ectal intercostal muscles between the ribs, the ental or internal intercostals have been removed to show the intercostal lymphatic plexus; 1, the thoracic duct near the chylocyst, it extends along the vertebral column nearly on the meson; 2, 2, trunks arising in the intercostal spaces; 3, 3, 3, lymphatic glands in the course of the vessels; 4, 4, large trunk conveying the lymph from the three or four intercostal spaces into the abdomen and then pouring it into the chylocyst; 5, 5, similar trunk on the left side; 6, 6, and 7, trunks on the right and left, from the intercostal spaces to the thoracic duct.

Right common lymphatic trunk (*truncus lymphaticus communis dexter, s. minor; vena lymphatica dextra*).—The right common lymphatic trunk is only about 14 mm. long, but is nearly as great in diameter as the thoracic duct. It is formed by the confluence of the lymphatics from the right side of the head (*truncus lymphaticus jugularis dexter*), those from the right arm, shoulder, and breast (*truncus lymphaticus subclavius*), the efferent trunks from the right half of the sternal, and ventral mediastinal and bronchial plexuses (*truncus broncho-mediastinalis dexter*). This common trunk, therefore, collects the lymph and pours it into the veins from the right half of the body, cephalad of (above) the umbilicus—part of the liver, the right lung, right side of the heart, right half of the head, face, neck, back, and part of the right intercostal region drains its lymphatics into the thoracic duct. As on the left side there is a tendency for the trunk to terminate by a multiple instead of a single opening. Not infrequently, there is no true common trunk formed, but the great trunks from the different regions open separately.

The great lymphatic trunks in the higher mammals conform quite closely to those of man, but the termination varies somewhat. When the internal jugular is small it is generally near the junction of the subclavian and external jugular (Figs. 4993, 4996, and 4998). In the horse this duct terminates in the precava, and in the ox usually at the junction of the left jugular and the precava. In the ox also it usually traverses a special opening in the diaphragm. In the horse the duct is ampullated at its termination, as it is also in the dog and rabbit (Figs. 4996 and 4998). In all the animals both trunks tend to open by two or more mouths (Fig. 4994), and in all the thoracic duct shows a strong tendency to conform to the lymphatics in general and break up into a kind of network instead of remaining of considerable size. Sometimes this network encloses the aorta, but more frequently it assumes the condition shown in Fig. 4994. In the rabbit almost constantly, and very frequently in the cat, there is a branch of the thoracic duct extending to the right (Figs. 4993 and 4998).

The chylocyst is large in the dog, cat, and rabbit, and in many other animals, and there is a strong tendency for its component trunks (intestinal and lumbar) to divide before entering it, so that it is formed by the union of a coarse network rather than by a few simple vessels (Figs. 4993, 4994, 4996, and 4998).

In the non-mammalia, birds, reptiles, amphibia, and fishes, the great trunks are symmetrical, that is, nearly equal on the two sides. They open into the great veins near the heart. There are also a pair of vessels opening into the ischiadic or other pelvic veins, and in the frog and toad there is a lymph heart on each great trunk near the opening. In the non-amphibian forms, where lymph hearts are present, they are confined to the pelvic region.

ORIGIN AND STRUCTURE OF THE LYMPHATIC VESSELS.—There are three distinct views as to the ultimate origin of the lymphatic vessels: 1. That they are in direct communication with the blood-vessels by means of connecting radicles so small that in normal conditions only the blood plasma can traverse them, and that under pathological conditions these connecting radicles may increase sufficiently in size to admit the passage of blood corpuscles. This was one of the earliest views, and it is supported by the fact of the ready appearance of water or even colored gelatin in the lymphatics soon after the blood-vessels is

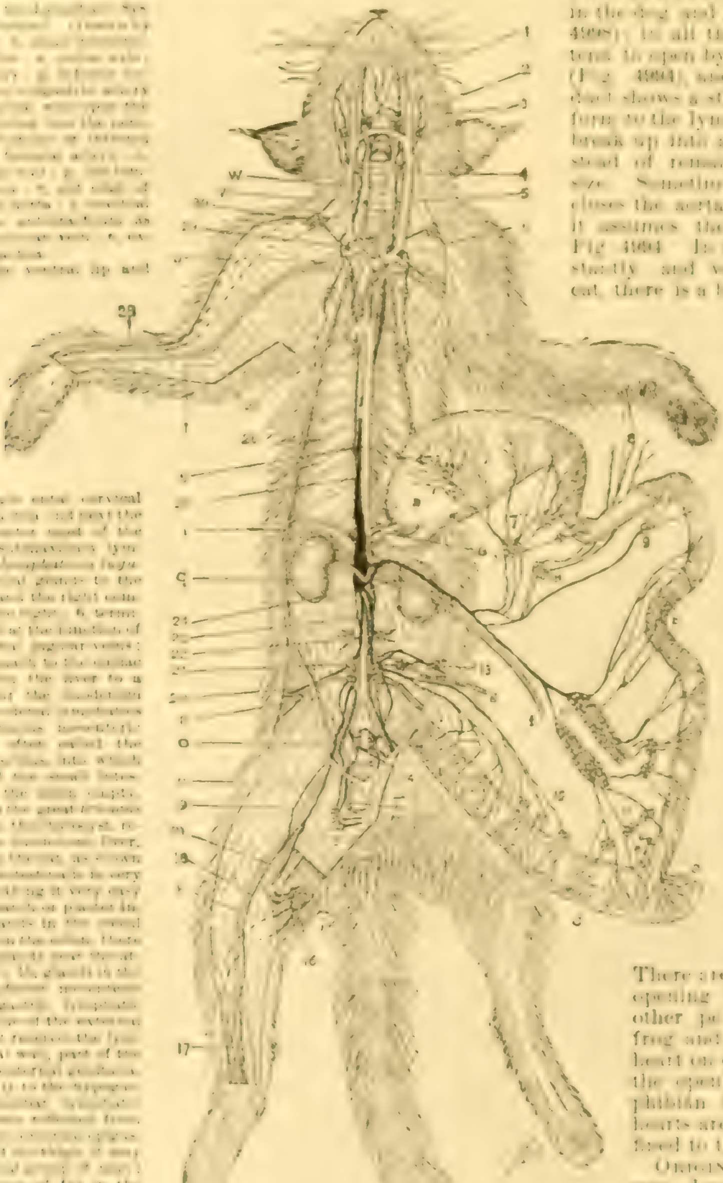
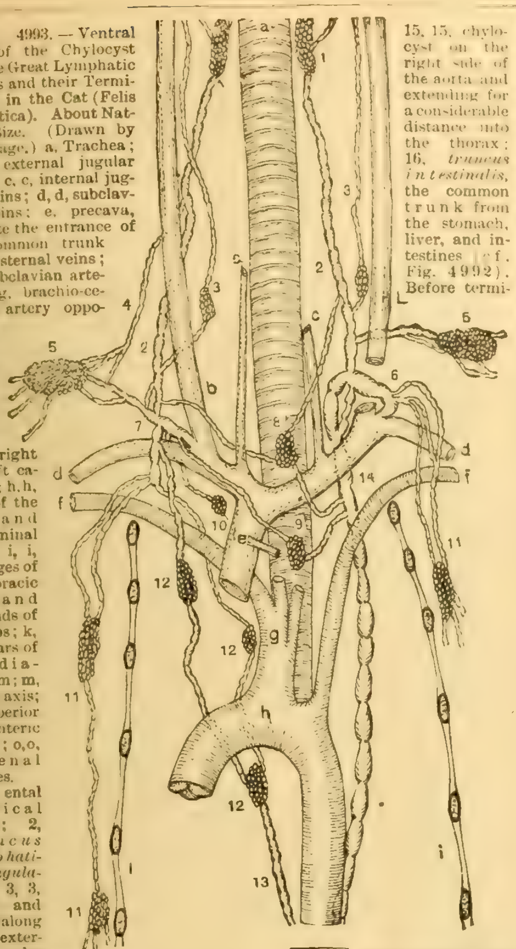


Fig. [illegible]



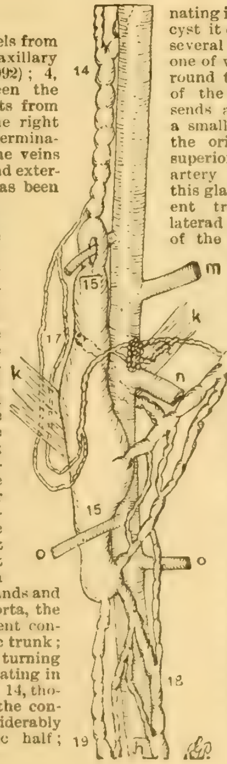


FIG. 4993.—Ventral View of the Chylocyst and the Great Lymphatic Trunks and their Termination in the Cat (Felis Domestica). About Natural Size. (Drawn by Mrs. Gage.) a, Trachea; b, b, external jugular veins; c, c, internal jugular veins; d, d, subclavian veins; e, precava, opposite the entrance of the common trunk of the sternal veins; f, f subclavian arteries; g, brachio-cephalic artery opposite its division into the right subclavian, the right and left carotids; h, h, arch of the aorta and abdominal aorta; i, i, cut edges of the thoracic walls and the ends of the ribs; k, k, pillars of the diaphragm; m, cœliac axis; n, superior mesenteric artery; o, o, the renal arteries.

1, ental cervical gland; 2, *truncus lymphaticus jugularis;* 3, 3, trunk and gland along the external jugular vein, the trunk is one of the efferent vessels from the lateral of the two submaxillary lymphatic glands (cf. Fig. 4992); 4, anastomosing branches between the jugular trunk and the efferents from the prescapular gland; 5, 5, the right and left prescapular gland; 6, termination of the thoracic duct in the veins at the angle of the subclavia and external jugular, a short segment has been removed from the external jugular to show more clearly the arch of the terminal part of the thoracic duct; 7, the right common lymphatic trunk at its termination; 8, lymphatic gland on the trachea, its efferent vessels extend both to the right and to the left; 9, large gland in the ventral mediastinum around the sternal vessels, its efferent vessels extend both to the right and to the left; 10, small gland about opposite the head of the first rib, there is one also on the left but it has been omitted; 11, 11, pectoral glands and lymphatic vessels, they follow the axillary blood-vessels after reaching the axilla and terminate directly in the arch of the thoracic duct on the left, but join other trunks on the right before entering the common trunk; 12, 12, 12, lymphatic glands and trunks near the arch of the aorta, the efferent vessels form prominent constituents of the right lymphatic trunk; 13, branch of the thoracic duct turning to the right and finally terminating in the right lymphatic trunk; 14, 14, thoracic duct. As indicated by the constrictions the valves are considerably farther apart in the cephalic half; 15, 15, chylocyst on the right side of the aorta and extending for a considerable distance into the thorax; 16, *truncus intestinalis*, the common trunk from the stomach, liver, and intestines (cf. Fig. 4992). Before terminating in the chylocyst it divides into several branches, one of which winds round the left side of the aorta, one sends a branch to a small gland near the origin of the superior mesenteric artery and from this gland the efferent trunk passes laterad of the pillar of the diaphragm, enters the thorax with the splanchnic nerves and terminates in the thoracic duct just beyond the chylocyst, still another branch anastomoses with the lumbar trunks; the lymphatics form a perfect maze in this region, so that it is no wonder Eustachius was bewildered in his first investigation of them; 17, lymphatic vessels from the abdomen to enter the thoracic duct in the thorax; this seems like an exact reversal of the condition in man where some of the lymphatics of the thorax (intercostal plexus) enter the abdomen to assist in forming the chylocyst (cf. Fig. 4991); 18, left and 19, right anastomosing trunks from the lumbar glands.

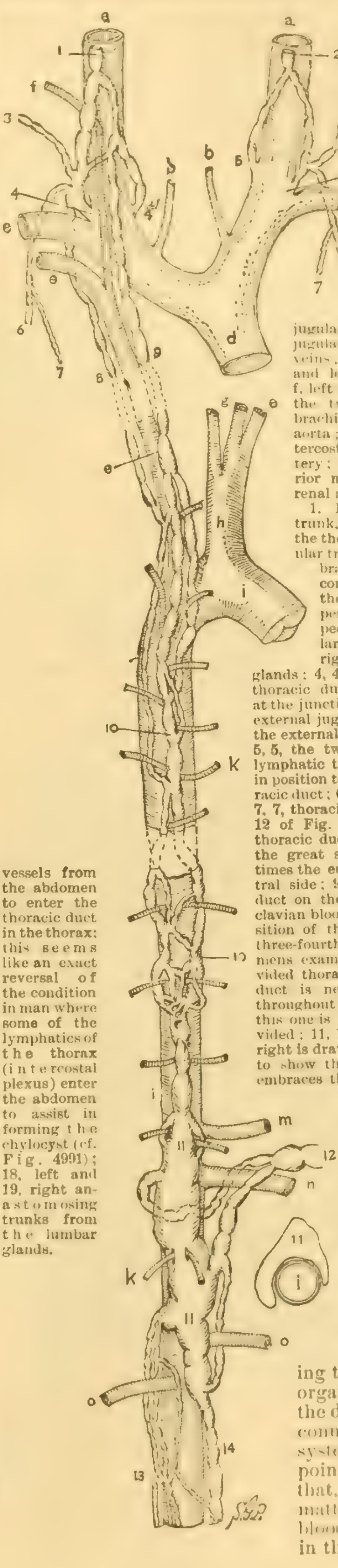
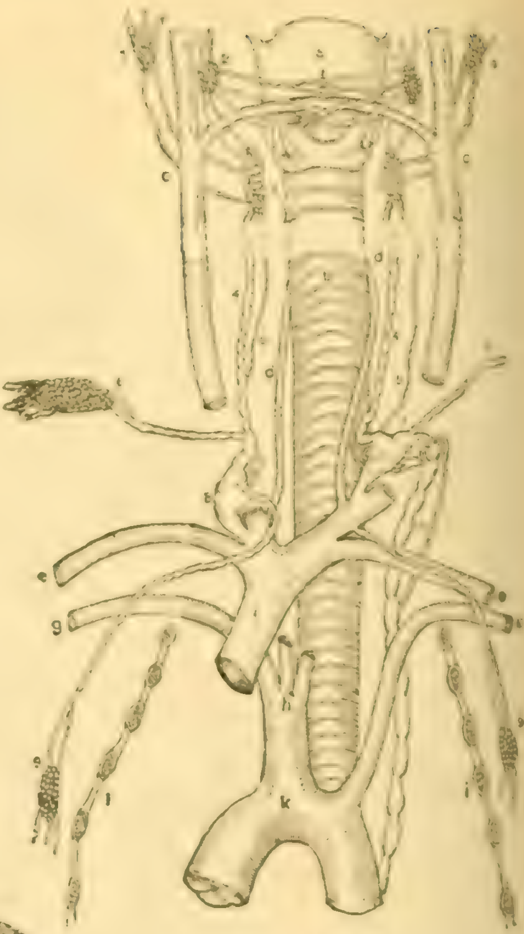


FIG. 4994.—Dorsal View of the Chylocyst and the Great Lymphatic Trunks in their Relation to the Blood-vessels of the Cat (Felis Domestica). Slightly more than Natural Size. The blanks and dotted lines indicate the omission of a part of the length. (Drawn by Mrs. Gage.) a, a, External jugular veins; b, b, internal jugular veins; c, c, subclavian veins, d, precava; e, the right and left subclavian arteries; f, left thyroid axis; g, between the two carotid arteries; h, brachio cephalic artery; i, i, i, aorta; k, k, upper one an intercostal, lower a lumbar artery; m, cœliac axis; n, superior mesenteric artery; o, o, renal arteries.

1. Left jugular lymphatic trunk, bifurcating and joining the thoracic duct; 2, right jugular trunk, bifurcating and one branch joining the right common lymphatic trunk, the other terminating independently in the mesal aspect of the external jugular; 3, 3, trunks from the right and left prescapular glands; 4, 4, the two openings of the thoracic duct, the lateral one being at the junction of the subclavian and external jugular, the mesal one into the external jugular about opposite; 5, 5, the two openings of the right lymphatic trunks—they are similar in position to the openings of the thoracic duct; 6, 6, pectoral lymphatics; 7, 7, thoracic lymphatics (cf. 11 and 12 of Fig. 4993); 8, branch of the thoracic duct on the ventral side of the great subclavian vessels, sometimes the entire duct is on the ventral side; 9, branch of the thoracic duct on the dorsal side of the subclavian blood-vessels—this is the position of the entire duct in about three-fourths of the numerous specimens examined; 10, 10, greatly divided thoracic duct. The thoracic duct is never simple in the cat throughout its whole course, but this one is more than commonly divided; 11, 11, 11, chylocyst. On the right is drawn a section at this point to show that the chylocyst nearly embraces the aorta; 12, intestinal lymphatic trunk sending a large branch on both sides of the aorta to enter the chylocyst; 13, left lumbar trunk greatly divided; 14, right lumbar lymphatic trunk anastomosing with the left and with a branch from the intestinal trunk.

were injected. This was, and still is, a favorite method of demonstrating the lymphatics of an organ. In objection to the doctrine of the direct connection of the two systems of vessels, it was pointed out by Hunter that, when the coarser matters injected into the blood-vessels appeared in the lymphatics, it was due to a leakage somewhere in the wall of the blood-vessel; and further, that the filling of the lymphatics by injecting water or gelatin into the blood-vessels was but natural, as it is one of the properties of the blood-vessels to allow the contents to diffuse through their walls and the lymphatics, from their office as a drainage system, take up the exuded liquid. This does not, however, show how the exuded liquid gets into the lymphatics. The pressure which forces the plasma through the walls of the blood-vessels would seem rather to collapse the lymphatics, as the pressure is in on the outside. In a word, there has been no conclusive proof given that there is or is not a direct connection between blood-vessels and lymphatics.

2. That there is a net-work of minute spaces in the tissues between and around the individual structural elements, through which the diffused plasma slowly moves, bathing all the cells and fibres, giving to them oxygen and the other nutritive elements, and taking in return carbon dioxide and the other products of waste. Part of this waste, especially the carbon dioxide, diffuses



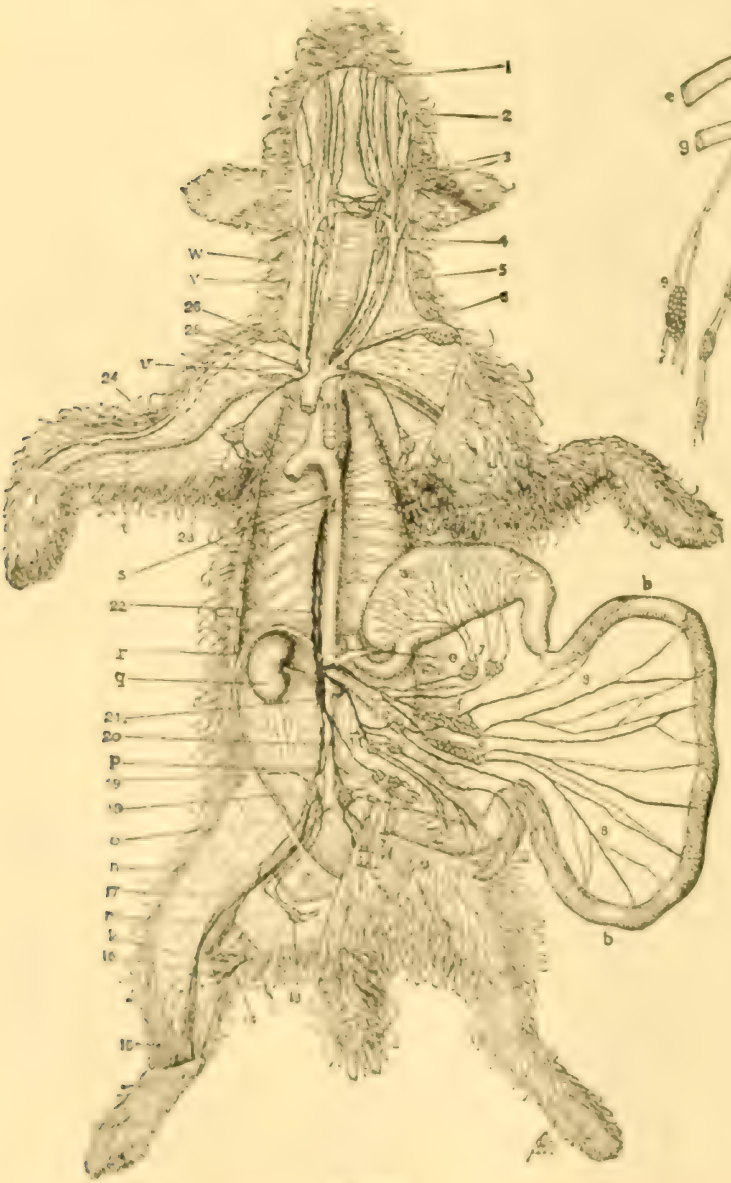


Fig. 4995.

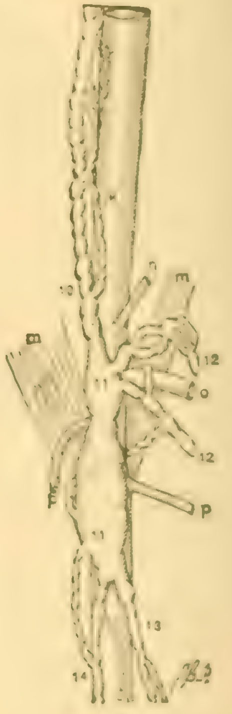


Fig. 4996.

Fig. 4995.—General View of the Lymphatic System of the Dog (Scotch Terrier). (Drawn by Mrs. Gage.) a, Stomach ; b, b, small intestine ; c, cæcum ; d, large intestine ; e, cœliac axis ; f, superior mesenteric artery ; **g, inferior mesenteric artery ; h, epigastric artery displaced from** the abdominal wall to the muscles of the thigh ; i, sciatic nerve and **other popliteal structures brought into view by removing a segment of** the thigh muscles ; k, saphenous or internal cutaneous artery ; m, n, the femoral artery ; o, cut edge of the abdominal wall ; p, ilio lumbar artery ; q, right kidney ; r, cut edge of the diaphragm ; s, aorta ; t, brachial artery and its continuation as the radial artery in the antibrachium ; u, subclavian vein ; v, external jugular vein ; w, trachea. 1, Lymphatic trunks from the ventral lip to the mesal of the two submaxillary lymphatic glands ; 2, lymphatic trunks from the face and **nose, and dorsal lip, injected from the snout ; 3, the two submaxillary** lymphatic glands with the facial vein between them—the mesal glands of the two sides are connected by several transverse vessels ; 4, ental cervical gland ; 5, jugular lymphatic trunk finally joining the thoracic duct on the left, the right lymphatic trunk on the right ; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins ; 7, cœliac glands receiving the lymphatics of the stomach, **and sending efferent trunks to the intestinal trunk ; 8, lymphatic** or lacteal trunks from the small intestine ; 9, two large mesenteric **glands (so-called glands of Asellius or pancreas Aselli ; from these orig**inates the intestinal lymphatic trunk, which is quite short in the dog **and much more difficult to inject than in the cat ; 10, gland receiving trunks from the duodenum, ileum, and large intestine near the cæcum ; 11, glands receiving the lymphatics from the cæcum,** and part of the large intestine ; **12, glands in the meso-colon along** the inferior mes**enteric artery ; they receive vessels from the large intestine, and the** efferent vessels go to the chylocyst and to the lumbar glands ; 13, gland on the abdomen beside the external epigastric artery ; 14, popliteal **gland ; 15, lymphatics from the foot, following the external or short** saphenous vein around the calf of the leg into the popliteal gland ; the parts of the vessels that would be hidden in this view are indicated by **broken lines ; 16, lymphatic trunk following the saphenous artery. The saphenous trunk freely anastomoses with the trunk following the femoral artery, and with it passes to the lumbar glands ; 18, lumbar** lymphatic glands ; 19, lymphatic trunk, accompanying the ilio-lumbar **artery, and terminating in the lumbar glands ; 20, lumbar lymphatic trunks ; 21, chylocyst ; 22, thoracic duct, double for a considerable** distance ; 23, pectoral lymphatic gland and vessels ; 24, lymphatic **trunks following the cephalic vein, and terminating in the prescapular gland. The course along the brachium is indicated by broken lines, as the vessels would not appear in this view ; 25, termination of the right lymphatic trunk ; 26, prescapular lymphatic gland of the right side.**

Fig. 4996.—Ventral View of the Chylocyst and the Great Lymphatic Trunks in their Relation to the Principal Blood-vessels of the Dog (Scotch Terrier). The blanks with dotted lines in the cervical region, and the blank in the thorax, indicate that part of the length has been omitted. About Natural Size. (Drawn by Mrs. Gage.) a, Larynx ; b, trachea ; c, c, the right and left external jugular veins, with segments removed ; d, d, the two internal jugular veins ; e, e, subclavian veins ; f, precava ; g, g, right and left subclavian arteries ; h, brachiocephalic artery, near its division into the subclavian and the two carotids ; k, k, aorta ; m, m, pillars of the diaphragm ; n, n, cœliac axis ; o, superior mesenteric artery ; p, p, renal arteries.

1, 1, Right and left lateral submaxillary lymphatic glands, receiving trunks from the face, nose, and dorsal lip ; 2, 2, mesal submaxillary **lymphatic glands, receiving trunks from the ventral lip ; these two** glands are connected by numerous anastomosing and crossing trunks ; 3, 3, ental cervical glands, receiving the efferents from 1 and 2 ; 4, 5, **4, 5, jugular trunks from the ental cervical glands to the thoracic duct and right common lymphatic trunk ; 6, 6, trunks from the prescapular** glands, only the right gland being shown ; **7, termination of the thoracic duct on the mesal surface of the external jugular, near its junction** with the internal jugular vein. **The arch in the duct is on the dorsal side of the great subclavian vessels, and it arches toward the meson instead of laterad as with the cat, and before terminating, enlarges considerably. Into the enlargement terminate the jugular trunks and the** one from the prescapular gland ; the enlargement narrows markedly **before entering the vein ; 8, enlargement and termination of the right lymphatic trunk ; 9, 9, pectoral glands and trunks ; the one on the left terminates independently in the lateral aspect of the external jugular, near its junction with the subclavian ; 10, 10, thoracic duct ; it is considerably divided just within the thorax, and then again just before enlarging near its termination ; 11, 11, chylocyst on the ventral, and** right side of the aorta, and extending for a short distance into the thorax ; 12, 12, intestinal lymphatic trunks, one branch winds round the left side of the aorta, and terminates finally on the right side of **the chylocyst ; 13, left lumbar lymphatic trunk ; 14, right lumbar lymphatic trunk.**

Fig. 4997.—General View of the Lymphatic System of a White Rabbit. (Drawn by Mrs. Gage.) *a*, Stomach ; *b*, *b*, small intestine ; *c*, *c*, cæcum ; ***d*, the so-called vermiform appendix ; *e*, large intestine ; *f*, cœliac axis ; *g*, superior mesenteric, and *h*, inferior mesenteric artery ; *i*, external** epigastric artery displaced from the abdominal wall to the muscles of **the thigh ; *k*, sciatic nerve and other popliteal structures exposed by** removal of a segment of the thigh muscles ; *m*, saphenous or internal cutaneous artery ; *n*, *o*, femoral artery ; *p*, cut edge of the abdominal **wall ; *q*, ilio-lumbar artery ; *r*, right kidney, the left has been omitted, although the beginning of the renal artery is shown ; *s*, cut edge of the diaphragm ; *t*, aorta ; *u*, brachial and ulnar artery ; *v*, subclavian** vein ; *w*, external jugular vein ; *x*, trachea.

1, Trunks from the ventral lip and sides of the mouth ; 2, trunks from the snout ; 3, the two submaxillary lymphatic glands on either side of the facial vessels ; 4, lymphatic glands near the base of the ear ; 5, ental cervical lymphatic gland ; 6, left jugular lymphatic trunk on its way to join the thoracic duct ; 7, thoracic duct near its termination in the vein ; 8, cœliac glands, receiving the lymphatics of the stomach ; 9, 9, lacteals from the small intestine to 10, the great mesenteric gland (gland or pancreas of Asellius) ; it gives rise to two intestinal trunks, which are short, small, and difficult to inject with a coarse mass ; 11, large mesenteric gland receiving the vessels from the mass of lymphoid follicles at the termination of the ileum ; 12, lymphoid tissue, *sacculus rotundus*, at the termination of the ileum ; 13, gland receiving the lymphatic trunks from the vermiform appendix ; 14, glands in the meso-colon along the inferior mesenteric vessels ; the efferent vessels pass to the lumbar trunks ; 15, hypogastric or sacral lymphatic gland ; 16, gland on the abdomen by the external epigastric vessels—it has been **displaced with the artery to the thigh muscles ; 17, popliteal glands** receiving vessels from both sides of the crus, sending efferent branches between the peroneal and tibial nerves to follow the femoral artery, and another to accompany the ischiadic artery ; 18, lymphatic trunks from the dorsum of the foot, winding round the tibial or outer side of the calf to join the popliteal gland ; 19, lymphatic following the saphenous artery ; it usually divides near the knee, sending one branch to the pop**liteal gland ; 20, lymphatic trunk extending along with the femoral ar**tery ; it is formed by the intimate anastomosis of those accompanying the saphenous and deep femoral arteries ; 21, lumbar lymphatic glands ; **22, subcutaneous lymphatic gland near the ilio-lumbar blood-vessels,** just at the lateral margin of the sartorius muscle ; the efferent lymphatics follow the ilio-lumbar vessels and enter the lumbar glands ; 23, lumbar lymphatic trunks, the right one is much more divided than the **left ; 24, chylocyst ; 25, thoracic duct ; this is almost invariably more or** less divided and sends out a considerable branch to the right lymphatic trunk ; 26, pectoral lymphatic glands ; 27, anastomosing trunks fol**lowing the radial and brachial artery to the axillary glands ; 28, trunk following the radial nerve, winding round the brachium to terminate in the axillary glands also ; the broken line indicates that** the trunk would be out of sight in this view ; 29, axillary lymphatic **glands ; these are not very closely connected with the axillary vessels ; 30, termination of the right lymphatic trunk.**

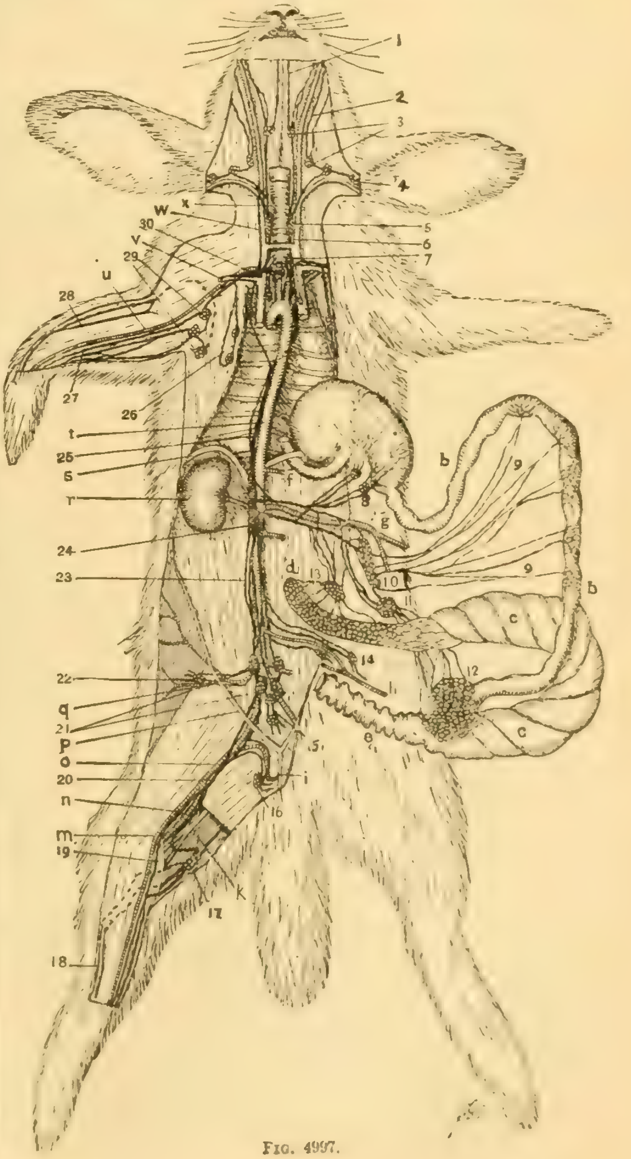
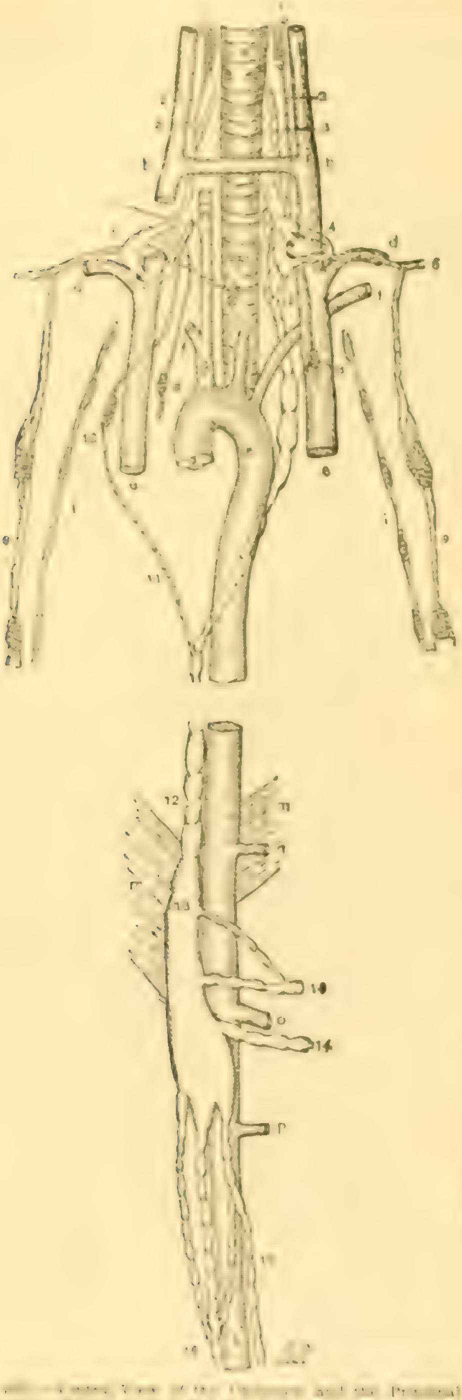
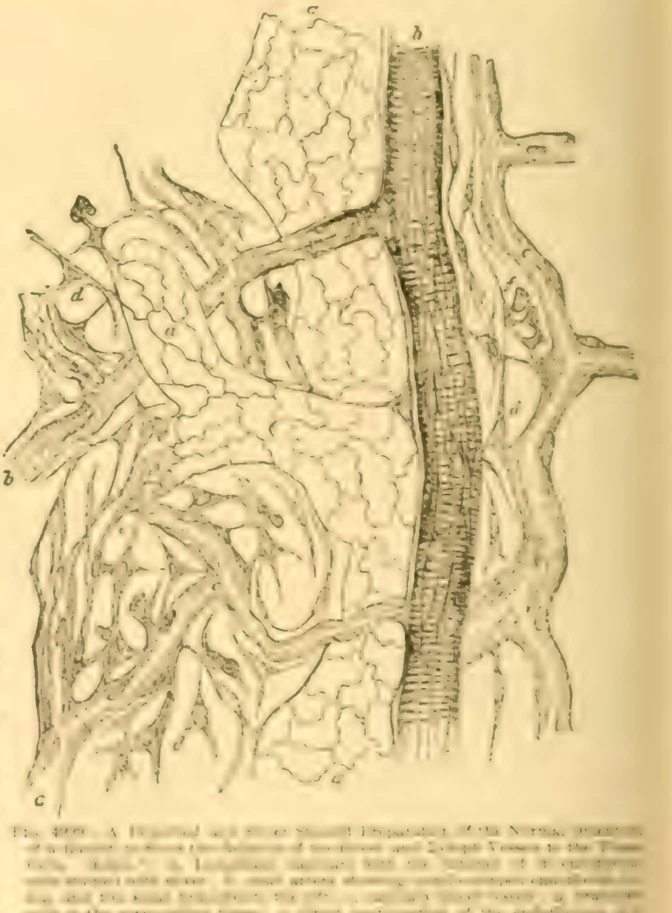


Fig. 4997.



[illegible]

back into the blood capillaries. This system has been called *juice spaces and canals* by Recklinghausen,[6] and the *lymph canalicular system* by Klein.[7] These minute channels and spaces are all interconnected and continuous with the blood vascular system through the intercellular cement and spaces, and with the lymphatic vessels in the same way, and further, these spaces frequently, if not constantly, contain branched cells, the cell body filling the larger spaces and the processes the connecting channels. These cell processes are often projected between the endothelial lining of the capillaries,



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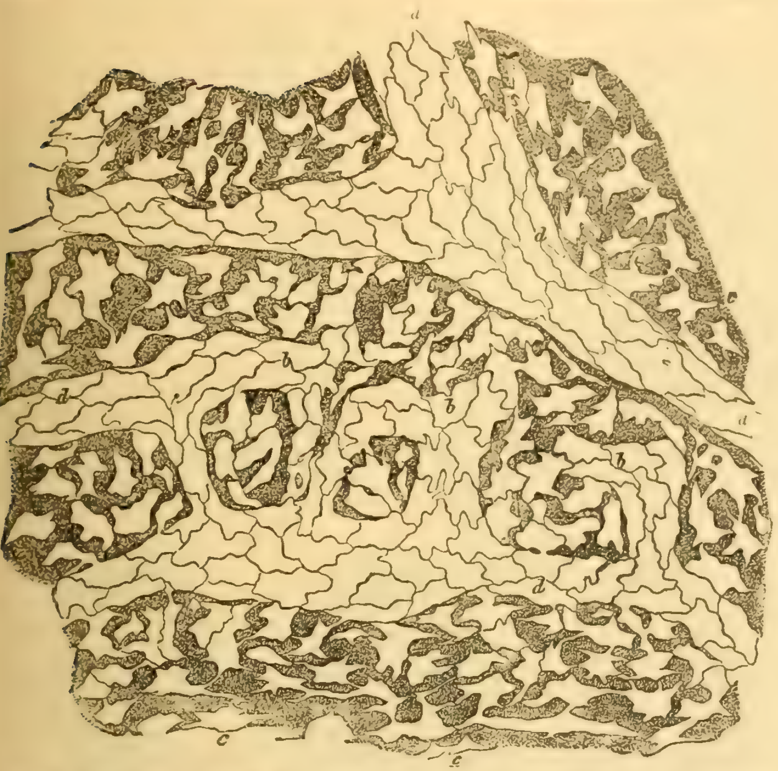

FIG. 5000.—Pencilled and Silver-stained Preparation of the Pleural Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Lymphatic Capillaries and their Relation with the Cell Spaces. (Recklinghausen.[8]) Magnified 300 diameters. *b*, Beginning of the lymph capillaries by a continuity with the cell spaces; *c, c, c*, cell spaces surrounded by the dark ground substance. These spaces contain cells, lymph-canalicular cells, and the cell processes partly fill the white lines connecting the cell spaces (*cf.* Fig. 4999). *d, d, d, d*, Lymphatic capillaries with the serrated endothelial cells.

thus forming the so-called pseudostomata, and therefore bring the lymphatics and blood-vessels really into continuity by the intervening cells and the spaces surrounding them. This is well shown at *e*, in Fig. 4999.

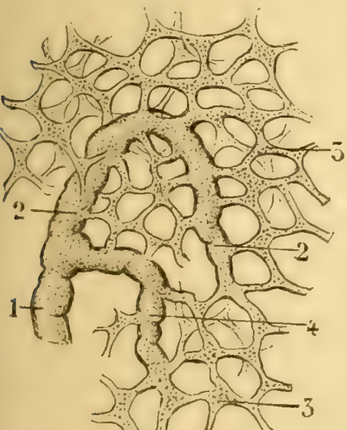

FIG. 5001.—Formation of a Lymphatic Capillary in the Skin of the External Ear. (Sappey, Atlas). 1, Lymphatic capillary; 2 and 4, two minute branches uniting to form the larger capillary; 3, 3, 3, lacunes or dilatations formed by the union of the minutest lymphatic vessels, the capillicules. The union of a multitude of these lacunes forms a lymphatic capillary. This is shown best at the lower part of the figure.

3. The third view is that of Sappey, who has represented with marvellous clearness the entire lymphatic system from origin to termination. He believes, and thinks he has proved by new and special means of research, that the lymphatic system at its origin is invariably composed of minute vessels (capillicules) from 1 μ to 4 μ in diameter, with structureless walls, which extend around and between all the structural elements. These capillicules are closed at the free end, but join, in nearly the same way as do the canaliculi of bone, to form somewhat larger spaces, the lacunes, which vary from 2 μ to 8 μ in diameter, and like the capillicules have structureless walls. By the union of many lacunes the true lymphatic capillaries are formed, and in them first appears the endothelial lining. Further, although the capillicules around and between the structural elements have blind terminations, those connected with the blood-vessels extend into the lumen between the endothelial cells, and have open mouths into which the plasma of the blood can freely enter, and in some pathological conditions they may become so large that the blood-corpuscles may pass through the capillicules to the lymphatic vessels. This view is in part a return to the original doctrine, and it also differs from the doctrine of the lymph canalicular origin in excluding the cells from the spaces or lacunes, and in giving distinct but structureless walls to the capillicules and lacunes.

The second view seems to the writer to be more in accordance with the teachings of modern biology and histology, by which the body is shown to be composed of a continuous net-work of interconnected structural elements, independent only in the form of blood-corpuscles, lymph-, and wandering-cells, but all the other elements being united either by cell cement or by delicate protoplasmic processes, and any spaces left between the structural elements being filled by the product of cell activity, which is known as ground or intercelluar substance. This is very abundant in some tissues, as cartilage, very slight in amount in others, as epithelia. All of these structural elements are constantly bathed with lymph, and it is more in accord with what is at present known of absorption and excretion (see article Nutrition, Vol. V.) to suppose that the lymph depends for its movement in certain definite directions upon the action of the living cells rather than on merely physical conditions. If this is the correct physiological view, then the anatomical structure of the lymph canalicular system and lymph canalicular cells of Klein seems most in harmony with the work to be done.

The readily demonstrated or apparent origin of the lymphatic vessels is in a plexiform network of valveless capillaries of varying sizes (Plates XXXIII. and XXXIV., and Figs. 5009 and 5010). From this capillary net-

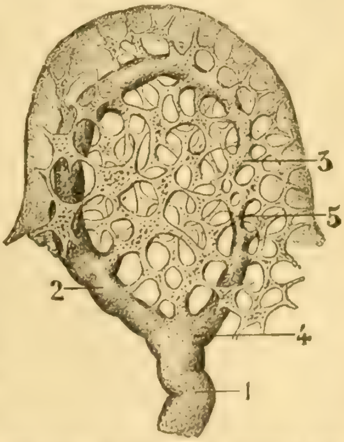

FIG. 5002.—Formation of a Lymphatic Capillary in the Papilla of the Skin of the Ear of Man. (Sappey, Atlas.) 1, Lymphatic capillary at the base of the papilla; 2 and 4, the two trunks of the capillary of origin uniting to form the large capillary; 3 and 5, the point of origin and connection of the two divisions of the capillary trunk. Between and around the originating capillary are the innumerable lymphatic lacunes which unite to form the capillaries, and also to enter them after their formation.

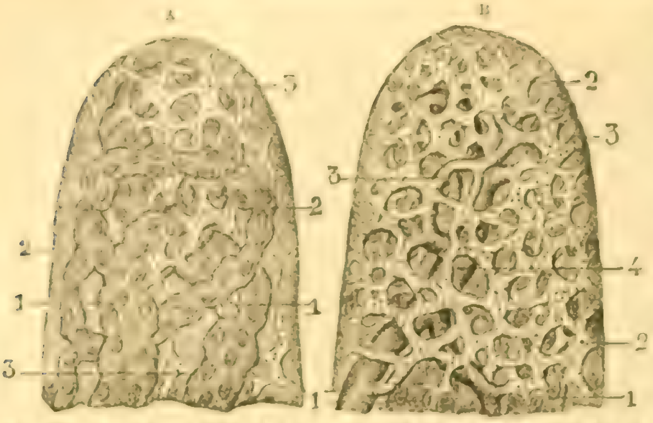

FIG. 5003.—Two Papillæ of the Lip to show the Relation of the Lymphatics and Blood-vessels. (Sappey, Atlas.) A, the blood capillaries, very few lymphatic capillaries and lacunæ being injected: 1, 2, anastomosing capillary loop; 3, lymphatic lacunæ. B, a similar papilla in which the lymphatic net-work is completely injected: 1, 1, blood capillaries with evident nuclei; 2, 2, net-work of lacunæ; 3, 3, lymphatic capillary uniting to form a considerable trunklet, 4.

work extend collecting trunks with abundant valves (Fig. 4978). The serous cavities are likewise directly connected with the lymphatic vessels through the stomata or pseudo-stomata (Figs. 5006, 5008). But according to Balfour and Hertwig the pleuro-peritoneal cavities are not primarily connected with the lymphatic system, but come to be so connected later. Budge has shown lately, however, that in the chick the connection with the body cavity is actually prior to the connection with the blood vascular system.

A distinct plexus of origin has been satisfactorily demonstrated in all the tissues and organs except the following, and in some of these, as the cornea, the lymph is known to circulate, although not in an independent net-work of vessels.

1. The central and peripheral nervous system and retina. The lymph in these situations is either in perivascular spaces or in perineurial spaces. In the optic nerve, however, Key and Retzius figure a well-defined lymphatic net-work.

2. A lymphatic net-work has not been satisfactorily made out for bone or cartilage, and Sappey denies their presence.

3. All forms of epithelia, including hair, nails, and teeth. But Klein figures and describes processes of branched cells projecting between epithelial cells and serving as lymph channels, but no distinct capillaries with endothelial walls are present.

4. Cornea and, according to Sappey, all forms of fibrous tissue, tendons, aponeuroses, fascia, and all serous membranes. Where a plexus of origin appears to be in these it belongs to the underlying tissue. According to many authors the connective tissue is a favorite place for the origin of the capillary lymphatic net-works. There is no doubt of the presence of the net-works, the only question is whether it belongs to the connective tissue or to the surrounding tissues.

The ducts of some glands (as the pancreas) have never yet been shown to contain lymphatics, although in the

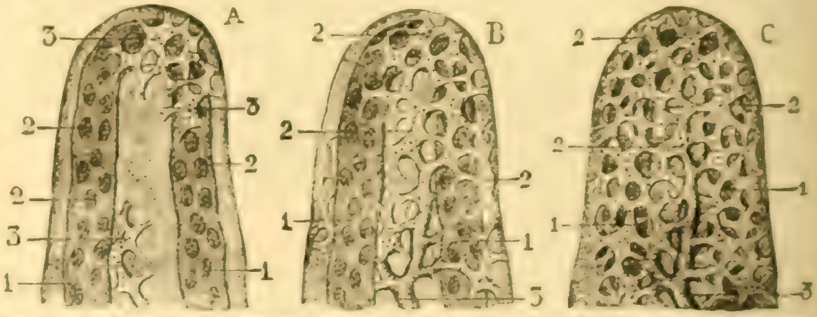

FIG. 5004.—A Simple Papilla from the Corium of the Hairy Skin of the Head, showing the Blood-vessels and Three Stages of Lymphatic Injection. (Sappey, Atlas.) A, a papilla, the simple blood capillary loop (1 and 2) with very few lymphatic lacunæ (3), and no sign of a lymphatic capillary. B, the lymphatic capillary (5) has appeared, and the lymphatic lacunæ and capillaries (2) are very prominent, but the blood capillary loop (1) is still evident. C, The blood capillary loop (1) is almost invisible from the dense net-work of lymphatic lacunæ and capillaries (2), the lymphatic capillary (3) is prominent. This series is an excellent illustration of the structures that remain invisible in ordinary preparations. Probably in very few histological preparations are more than half or one-third of the structures seen.

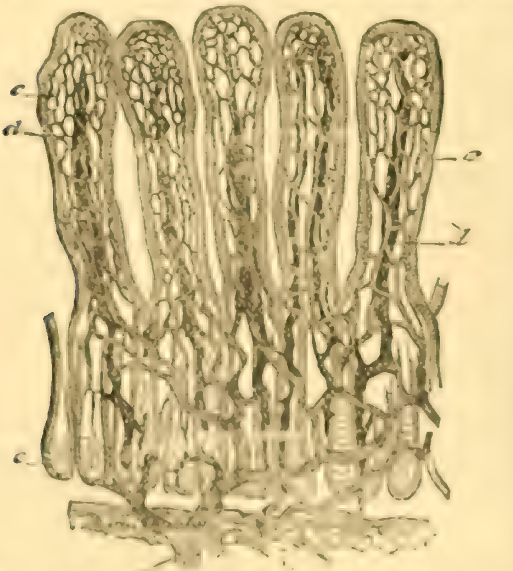

FIG. 5005.—Lacteals of the Intestinal Villi of the Dog. [illegible] a, Artery extending into the villi to form a capillary net-work [illegible]

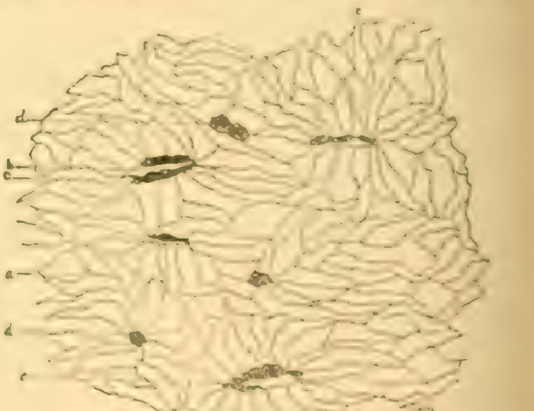

FIG. 5006.—Portion of the Cisterna Lymphatica Magna of the Frog, to show Endothelium and Stomata. (Ranvier.) a, ordinary endothelial cells, the nuclei not being shown; b, b, stomata leading from the peritoneal cavity into the dorsal lymph sac; c, c, germinating endothelium surrounding the stomata; d, germinating endothelia among the ordinary cells; these are frequently called pseudostomata.

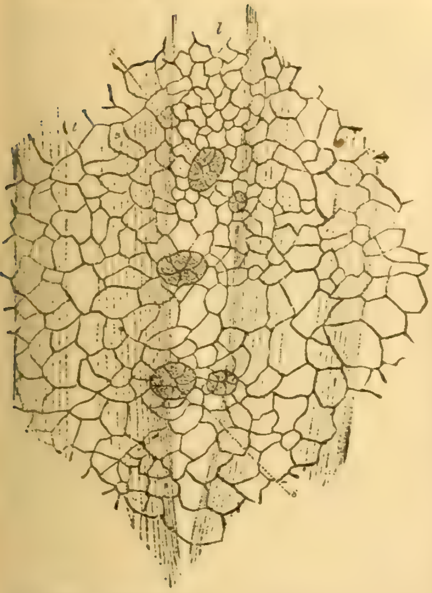

FIG. 5007.—Silver-stained Peritoneal Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Stomata. (Klein[7].) *l*, Lymph channel between the tendon bundles; *s*, *s*, five stomata, surrounded by germinating endothelium and leading into the lymph channel between the two tendinous bundles. Part of the stomata are open and part closed; *t*, *t*, two bundles of the central tendon, between which is the lymph channel into which the stomata open. Over the tendinous bundles the endothelial covering is composed of markedly larger cells than over the lymph channel.

ducts of other glands, as the liver, lymphatics have been shown in great numbers.

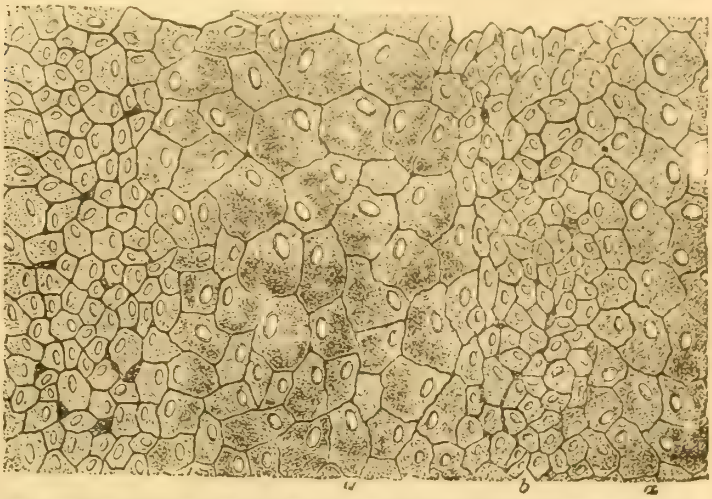

FIG. 5008.—Peritoneal Endothelium from the Central Tendon of the Rabbit's Diaphragm, to show the Difference in the Size of the Cells, and the Pseudostomata between them. (Klein.) *a*, *a*, Irregular rows of large nucleated endothelial cells, corresponding to underlying tendinous bundles; *b*, rows of smaller endothelial cells with numerous pseudostomata between them (the dark spots). The rows of small cells correspond to the lymph channels between the bundles (cf. Fig. 5007).

These net-works or plexuses of origin show considerable variety in different parts of the body. As a rule, the lymph capillaries are considerably larger than the blood capillaries (Fig. 5010), and there is a great tendency to form blind, often ampulliform enlargements (Fig. 5010). In the villi of elongated narrow form, the origin by a blind central vessel is normal, or there may be a simple loop instead (Fig. 5005). In man, where the villi are mostly short and broad, there is a complicated net-work something like the blood capillaries, except that the lacteal capillaries are much larger. The simple blind end and loop are also seen in some of the more elongated villi. The presence of

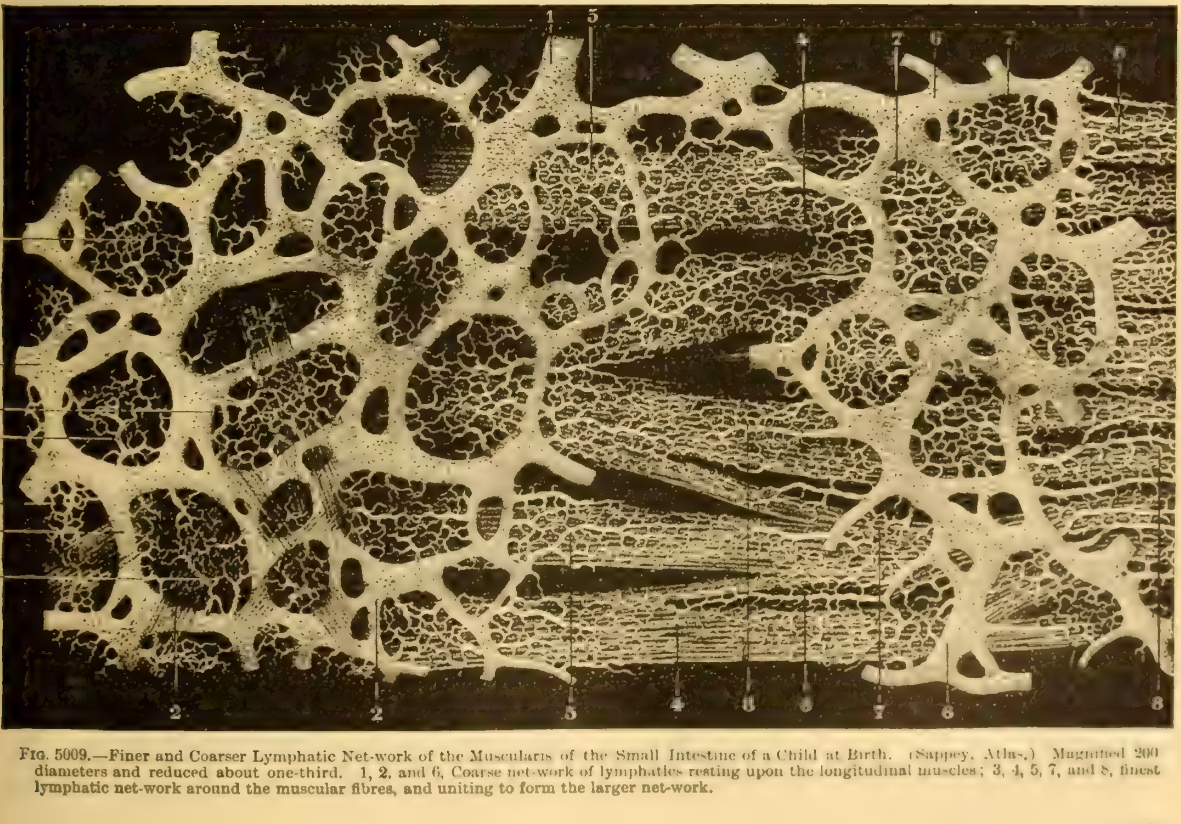

FIG. 5009.—Finer and Coarser Lymphatic Net-work of the Muscularis of the Small Intestine of a Child at Birth. (Sappey, Atlas.) Magnified 200 diameters and reduced about one-third. 1, 2, and 6, Coarse net-work of lymphatics resting upon the longitudinal muscles; 3, 4, 5, 7, and 8, finest lymphatic net-work around the muscular fibres, and uniting to form the larger net-work.

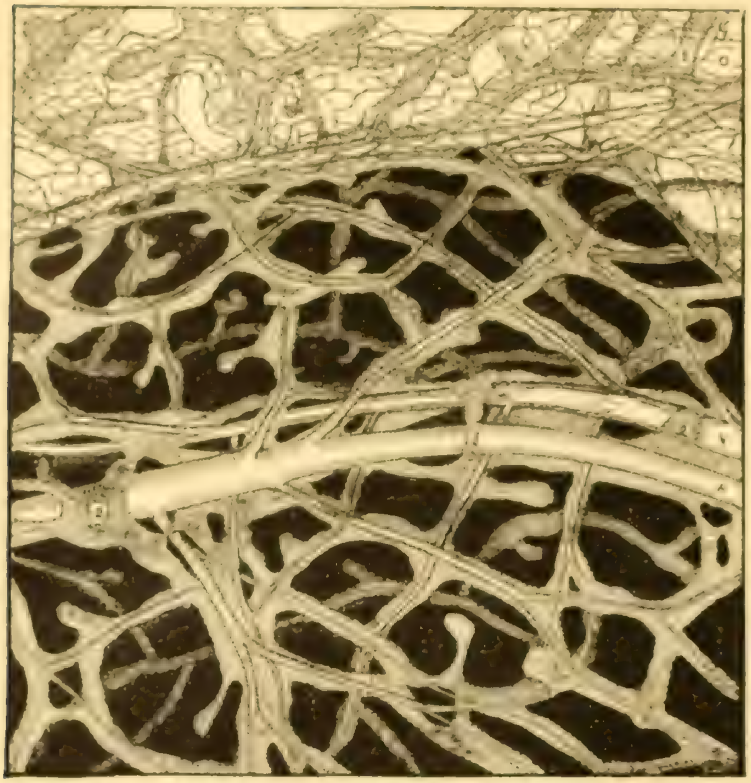

FIG. 5010.—Lymphatic Network in the Submucosa of the Rabbit's Cæcum, showing the Form of the Network and the Relation of the Lymphatics and Blood-vessels. Magnified 55 diameters. (Drawn by Mrs. Gage.) A, A, small arteries; V, small vein; C, the blood capillaries at the upper part of the figure; 2, 2, 2, 2, lymphatic vessels. Many of the vessels have blind projections, and throughout the entire figure is shown the tendency of the lymphatics to follow the blood-vessels and partly surround them. The preparation was made by direct [illegible] into the appendix vermiformis, when it extended into the submucosa of the adjoining part of the cæcum (see Fig. 4997). The blood-vessels were then injected with fine red gelatin mass from the superior mesenteric artery. After the gelatin had cooled the cæcum was distended with alcohol, and the preparation finally mounted in Canada balsam.

ampulliform enlargements, or even blind endings, in a vessel is not enough to determine whether it is a blood-vessel or a lymphatic, for some blood-vessels in muscle (Ranvier) and in the dura of the brain (Key and Retzius) have the form which is usually considered so characteristic of lymphatic vessels. The final test must be the connections of the vessel with a lymphatic gland or with an undoubted blood-vessel.

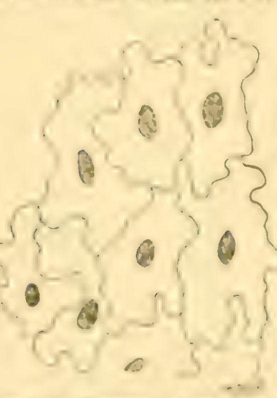

FIG. 5011.—Endothelial Cells from a small Lymphatic Capillary of the Central Tendon of the Rabbit. [illegible] (Gage.)

Structure of Lymphatic Vessels.—Beginning with the lymph capillaries the wall is composed only of endothelial cells arranged mostly in the form of a tube. They may, however, be more like flattened clefts, the walls of which are in apposition except when containing lymph. The lining cells have sinuous edges (Fig. 5011). On the larger vessels the lining endothelium has more elongated cell outlines (Fig. 5012), and there progressively appear coats like those of the blood-vessels, except that they are thinner. The adventitia is easily separated from the vessel, is composed of a network of fine elastic fibres and a few longitudinally arranged muscular fibre-cells. The middle coat has, besides the fine elastic tissue, many circularly arranged muscular fibre-cells. This circular arrangement is not strictly adhered to, especially in the thoracic duct. Finally, the inner layer has its elastic fibres mostly in a longitudinal direction, and the endothelium covers the inner surface. In the thoracic duct there is usually a considerable addition of white fibrous tissue to the middle layer, and, as stated above, many of the muscular fibres of this layer may be oblique or even longitudinal. In general, then, the lymphatic vessels agree with the veins quite closely in structure. The amount and the fineness of the elastic tissue present is supposed to exert a marked influence in causing the speedy return of the vessel to its normal calibre after its distention by the lymph.

Like the veins, the lymphatics are distinguished by the presence of valves, but they are much more abundant, there being, for example, sixty to eighty double valves from the hand to the axilla (Fig. 5013). In examining a well-injected preparation, it is very easy to determine the direction of the lymph stream as the segments of the vessel are approximately conical, the apex of the cone pointing in the direction of the stream (Fig. 5013). This is more marked in the smaller than in the larger vessels.

Valves are not found in the lymphatics of animals below the amphibia, and are much less numerous in amphibia, reptiles, and birds, than in mammals. The development of lymphatic vessels, so far as has been investigated, agrees closely with the development of blood-vessels.

LYMPHATIC GLANDS AND LYMPHOID TISSUE.—The lymphatic glands or ganglia or conglobate glands are rounded or flattened bodies placed in the course of the lymphatic vessels. These glands were known to Hippocrates, but were considered by him as forming a part of the general glandular system. Naturally their true nature was discovered only after the discovery of the lymphatic vessels. In the higher mammals it is believed that no lymphatic vessel reaches one of the common terminal trunks without first traversing one or more of these glands. They do not appear until we reach the birds, or perhaps some of the highest reptiles, but lymphoid tissue is present in all the forms; and as the glands are practically concentrations of this lymphoid tissue their absence is not so important as might at first appear. The glands are sometimes solitary but usually are in groups or chains; they are mostly near blood-vessels, and so placed and loosely attached that they readily move aside to avoid pressure. In the limbs pressure is further avoided by position in the flexures of the joints. The glands vary greatly in number and size in the different mammals. In man they reach the highest number (300 to 600), and vary from a few millimetres to two or more centimetres in diameter.

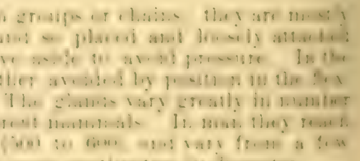

FIG. 5012.—Nucleated Endothelial Cells from one of the Larger Lymph-Channels of the Central Tendon of the Rabbit's Diaphragm, to show the Elongated Form of the Cells in the Larger Vessels. Cf. Fig. 5011. (Gage.)

Afferent and Efferent Vessels.—The vessel approaching a gland is said to be afferent or inferrent; the one leaving the gland is called efferent. On approaching a gland the afferent usually breaks up into several smaller vessels which enter the gland (Figs. 5013 and 5014). After traversing the gland the vessels leaving the surface unite usually in larger trunks than the afferent vessels, and continue to the next gland, where the process is repeated, or the vessel may terminate in one of the common trunks.

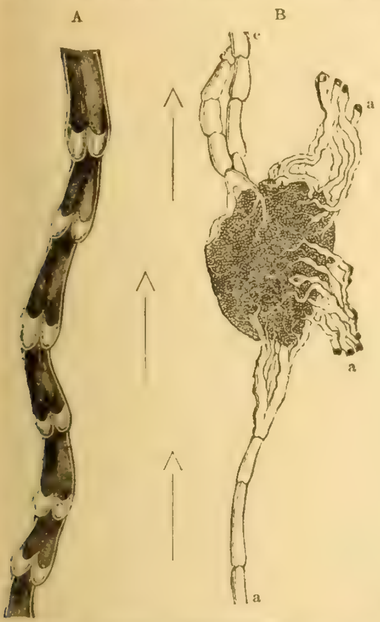

FIG. 5013.—Valves of a Lymphatic Trunk, and a Lymphatic Gland with its Afferent and Efferent Vessels. (Sappey.) A, Lymphatic trunk slit lengthwise and opened to show that the valves are in pairs—they are close together and they are at the level of the enlargements; further, that the intervalvular segments are in general of a conical shape, the apex of the cone pointing in the direction of the current, up in this figure. B, Lymphatic gland; a, a, a, the numerous afferent lymphatic vessels; e, the two voluminous efferent lymphatics.

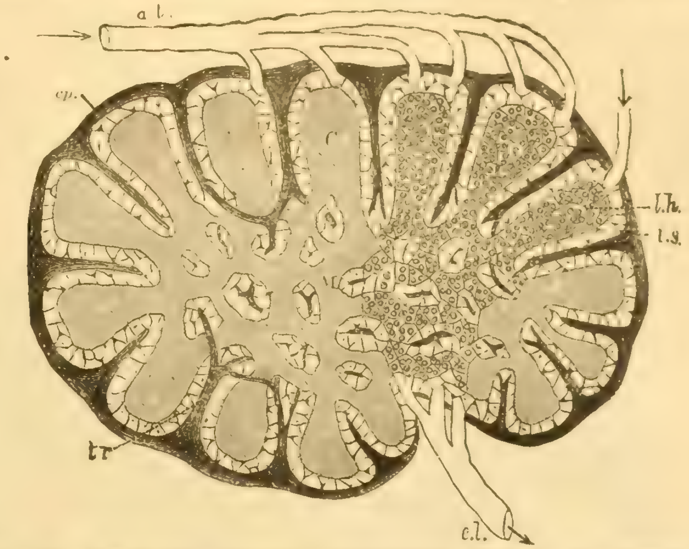

FIG. 5014.—Diagrammatic Section of a Lymphatic Gland. (Sharpey.) *a.l.*, Afferent trunk breaking up into several smaller trunks before entering the gland; *e.l.*, efferent lymphatic trunk formed by the union of several smaller trunks emerging from the gland (the arrows indicate the direction of the current); *C*, cortical glandular substance; *cp.*, capsule sending septa into the gland; *i.h.*, reticulated cords of medullary substance (it is shown in only a small part of the figure; the entire area shaded with lines possesses similar glandular substance); *l.s.*, lymph-sinus or channel; ***M***, central or medullary part of the gland (it is directly continuous with the cortical substance); *tr.*, trabeculæ or fibrous substance continuous with the capsule and forming a coarse meshwork in the gland (in this mesh is the proper gland substance).

The structure of the lymphatic glands was long enigmatical. It was held by many, and is still so held, that the gland was really a kind of fine capillary net-work, like a renal glomerulus or a rete mirabile, of blood-vessels; but it is now quite generally agreed that a lymphatic gland consists of the following parts: (1) A fibrous framework forming an enclosing capsule and sending into the interior a multitude of anastomosing trabeculæ. The capsule and larger trabeculæ may also contain muscular-fibre cells. (2) Embedded in the meshes of this fibrous net-work is the proper glandular substance, which consists of lymphoid tissue; that is, a fine net-work of branching and anastomosing cells and fibres containing in their meshes lymphoid corpuscles or young lymph-cells. Near the surface of the gland the lymphoid tissue is arranged in quite regular masses (cortical lobes or alveoli) by the projecting trabeculæ (Fig. 5014). This is the so-called cortical portion, while in the central part (medullary portion) the lymphoid tissue is in more cylindrical masses (the medullary cylinders or lymphoid cords), but the tissue in the two parts is directly continuous. (3) The lymph-sinus or channel. This is the path taken by the lymph in passing through the gland from the afferent to the efferent vessels. It is a narrow space filled with rather coarse reteform tissue, between the proper glandular substance and the fibrous framework (Fig. 5014, *l.s.*). The relations of this space may be clearly understood by comparing the fibrous framework to a mould and the proper glandular substance to the material poured into the mould and which, upon cooling, had shrunken evenly from the mould throughout the entire gland, thus leaving a narrow space which would represent the lymph-channel. The afferent lymph-vessel penetrates the sheath or capsule of the gland and pours its contents into the lymph-sinus.

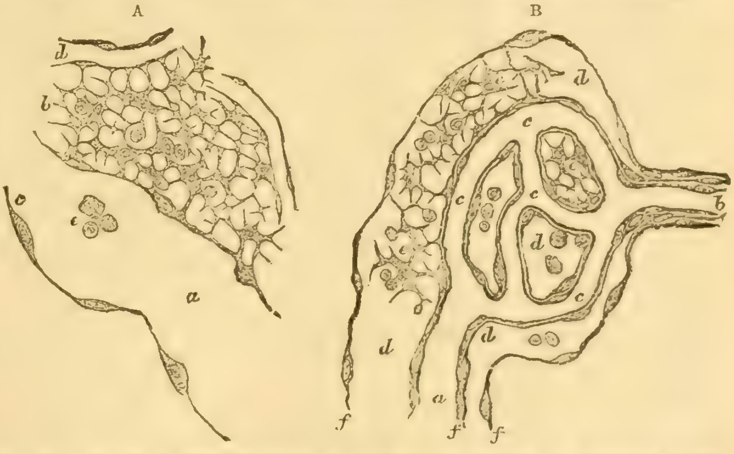

FIG. 5015.—Figures of Fresh Preparations of an Œdematous Omentum of a Guinea pig suffering from Chronic Peritonitis, to Show Developing Lymphatic Nodules seen in Optical Section. (Klein.[7]) A, Perilymphatic or lymphangial nodule; *a*, lymphatic vessel, *b*, a portion of the lymphangial nodule on the side of the vessel; *c*, endothelial wall of the lymphatic seen in profile; *d*, blood-capillary of the nodule; *e*, lymph corpuscles in the lymphatic vessel (this nodule is like the reticular substance forming the proper glandular substance of the lymphatic glands, and as seen both in A and B the cells of the reticulum are in direct connection with the endothelium of the lymphatic vessel). B, An endolymphatic or lymphangial nodule in which the reticular tissue is within instead of being on the side of the vessel *a*, vein; *b*, artery; *c*, blood-capillaries; *d*, a lymphatic vessel enclosing the whole system of blood-vessels; *e*, reticulum of nucleated branched cells or lymphoid tissue connected with the wall of the lymphatic and filling the entire lumen.

The lymph thus slowly moves among the labyrinthine channels until it reaches the efferent vessels, when it enters them and continues toward the common lymph trunk. In passing through the sinus the lymph bathes the glandular substance and probably leaks into it. Along the edge of the channel the newly developed lymph cells enter the lymph-stream and are carried along to the efferent vessel.

Blood-vessels are very abundant in the lymphatic glands and are found almost exclusively in the proper glandular substance. These blood-vessels are also accompanied by nerves. In some glands the efferent vessel and the blood-vessels are found mostly in a small depression which, in analogy with the kidney, has been called the hilum. This is not a marked feature and is absent in many cases.

In infancy and youth the glands near the surface are grayish in color while those in the interior of the body are pinkish. In adult and advanced life the glands are usually somewhat atrophied and darker in color, and those of the bronchial plexus are often dark brown or even black.

Lymphoid or adenoid tissue is like that described for the proper glandular substance of the lymphatic glands; that is, a fine net-work of branching and anastomosing cells or fibres with the meshes crowded with lymphoid cells. Sometimes this tissue is quite sharply defined, when it is called a follicle or simple lymphatic gland; in other situations it is diffuse. The tissue is abundantly supplied with blood-vessels, and the lymphatic vessels on its surface and emerging from the interior are in great abundance (Fig. 5016). The diffuse and follicular form of the tissue is found in great abundance in the alimentary canal of man and the lower animals. In the tonsils and the pharyngeal tonsil it is aggregated in considerable masses; so also in the Peyerian patches, which are simply an aggregation of lymph nodules, follicles, or solitary glands. The mucosa of the vermiform appendix of the rabbit (Fig. 4997) is almost entirely occupied by a great Peyer's patch; and the so-called solitary glands (Fig. 5016) are lymphoid nodules or follicles with a dense mesh-work pervaded by blood-capillaries and filled with lymph corpuscles. They are surrounded by a capillary net-work which helps to separate them somewhat from the surrounding less condensed lymphoid tissue (Fig. 5016).

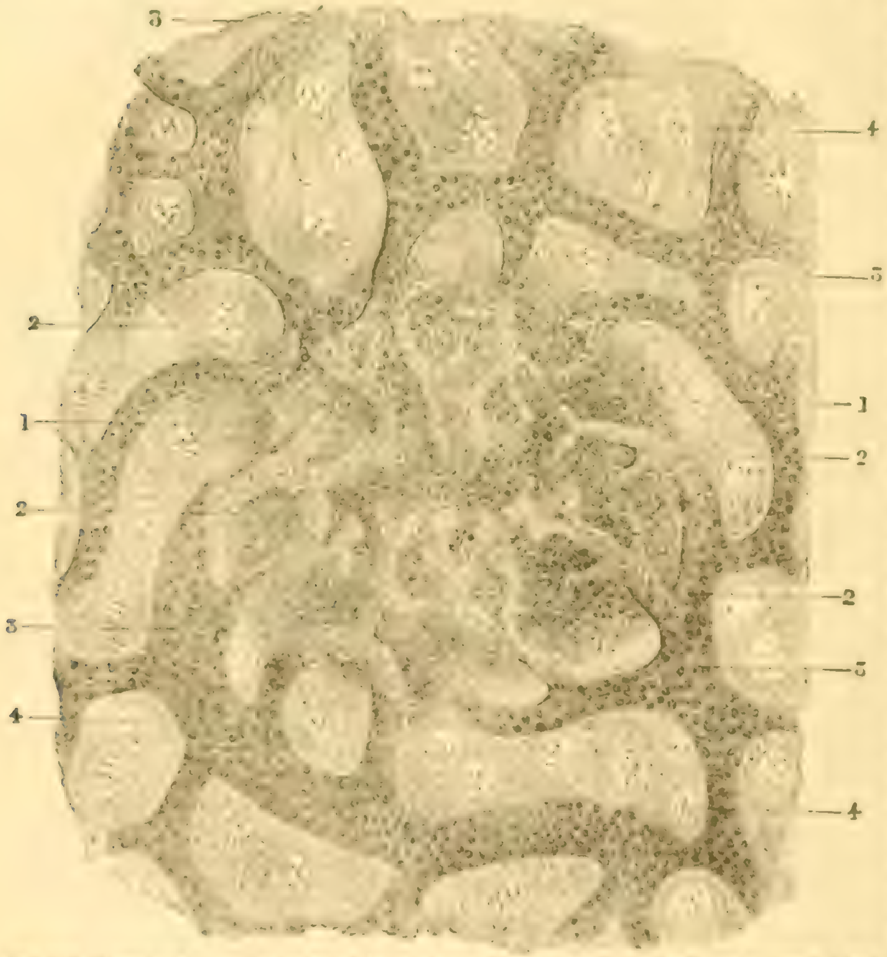

FIG. 5016.—Lymphoid Tissue arising from a Lymph-follicle or Solitary Gland of the Large Intestine of Man. [illegible] 1, [illegible] Lymph-follicles [illegible]; 2, 2, 2, 2, Lymphatic [illegible] in the depth of the follicle and ascending to the surface; 3, 3, 3, [illegible] formed by the orifices of the [illegible]; 4, 4, four of the crypts of Lieberkühn.

PHYSIOLOGY.—The blood- and lymph-vessels form part of the great circulatory system by which fluids are conveyed to and from the tissues, carrying in solution all the elements needed for nutrition and growth and removing waste. In describing the more marked part taken by each division of the system the blood-vessels have been very aptly described as a system of irrigation channels, and the lymphatics as drainage canals. This does not of course express the whole truth, for the veins are likewise drainage canals, and the lymphatics and their continuation, the lymph channels, supply nutriment and remove waste in situations where no blood-vessels are found, as in the cornea.

In the first enthusiasm over the lymphatic system, especially the lacteals, whose function seemed pre-eminently that of absorption, it was believed that all the absorption done in the body was by the lymphatic system. The blood-vessels conveyed the nutritive media to the tissues, and all waste or superfluous matter, and all food, found their way to the blood through the lymphatics. But the careful experiments of Magendie and others on absorption from the alimentary canal, the real stronghold of the lymphatics, showed that the blood-vessels also absorb, and the final outcome physiologically is that the lymphatic system is considered simply as an aid to the blood-vascular system. It is a remarkable fact that while with all the mammals the intestinal lymphatics absorb a great amount of the emulsified fat so that the connecting trunks are white from the contained chyle, in the animals below the mammals—at least, the birds, reptiles, and amphibia—the lymphatics of the intestine never appear white, and the natural inference is that the fatty food does not reach them. This subject of the absorption from the alimentary canal of these lower forms requires a thorough investigation.

Besides the absorptive action of the lymphatic system, it is a great manufactory of white blood-corpuscles

This takes place mostly in the lymphoid tissue in the lymphatic glands, and in this tissue wherever it is found. It is also thought by many investigators that the lymphoid tissue has to do also with the production of red blood-corpuscles.[12]

The movement of the lymph-stream is slower than that of the blood-stream, moving only 230 to 300 mm. in a minute in a large lymphatic of a horse. The flow of the lymph is dependent on several different factors: (1) The vessels, being so well supplied with valves, are able to make all movement due to outside pressure serve to produce an onward current; (2) the walls of the lymphatic vessels are contractile, owing to the muscular-fibre cells present, and these by their slow contraction—a contraction which has been seen to be rhythmical in some cases—aids in keeping the lymph in motion: this contraction has been observed in the lymphatics of man as well as of animals; (3) the intestinal villi contract vigorously, thus giving the chyle its initial movement; (4) the muscular tissue in the capsule, and sometimes also in the trabeculæ of the lymphatic glands, is supposed to compress the gland and thus hasten the flow through it. This would, however, only partly compensate for the retardation in traversing the narrow and greatly obstructed passages in the gland; (5) the aspiration of the thorax. This tends to suck the lymph of the terminal trunks into the veins. With the thoracic duct it tends to fill the whole duct, and then, from the abundance of valves, the pressure of expiration forces the lymph into the vein in jets; (6) on the principle of Sprengel's air-pump the more rapidly moving stream in the larger trunks tends to suck the lymph from the smaller branches, and the rapidly moving blood in the veins has the tendency to draw the lymph into the veins, any reversal of the current being guarded against by the presence of the valves at the openings; (7) doubtless the most important factor in the movement is the pressure at the periphery, a pressure really originating in the left ventricle of the heart.

Methods.—The lymphatic vessels are so thin that unless they contain some liquid or solid they are not visible. One of the first ways of making the general lymphatics visible was to inject water or colored gelatin into the arteries of an organ. The mass exudes and fills the lymph-vessels; this is especially successful if the vein is tied. The lacteals are made evident by feeding the animal some fatty food, like milk, an hour or two before death.

Vessels of sufficient size may be injected centrad with starch or plaster-of-Paris. It is not necessary to tie the cannula in place; simply pressing upon it with the fingers is sufficient. The insertion of the cannula is greatly facilitated by first inserting a beaded bristle into the lymphatic, then by raising the bristle the cut in the vessel may be seen. Where the vessels are too small to be seen, very successful injections may be made by the puncture method. That is, a hypodermic cannula is connected with a syringe or a constant-pressure apparatus, and inserted where lymphatics are supposed to be. The cannula is forced in as in ordinary hypodermic injections, and the mass allowed to flow or it is forced in. If the attempt is successful, the fine net-work and collecting trunks of a limited area will be injected. The toes and the finger-tips of man are favorite places for injection. In animals the pads of the feet and the bare spot on the snout are good. A lymphatic gland is always easy to inject. For a mass, mercury is generally used, but colored gelatin has the advantage of cheapness and of flowing readily through the glands in the course of the vessels. An excellent gelatin mass is Hoyer's chrome yellow: dry gelatin, 15 grams; water, 75 c.c. After the gelatin is added it is melted over a water-bath, and heated to 80° C., then 75 c.c. of a cold saturated solution of bichromate of potash, heated to 80° C., is added to the gelatin; finally, 75 c.c. of a cold saturated solution of acetate of lead is heated to 80° C. and added with constant stirring.

The puncture method was used by Hunter, Mascagni, and Cruikshank. Cruikshank, in his "Anatomy of the Absorbing Vessels" (1790), p. 44, says: "I have sometimes injected the lacteals from punctures made by the side of the veins where I knew they must be, though they were then invisible to the naked eye." He also injected the lymphatic glands by puncture.

Young animals are best for studying the lymphatics, and the leaner the animal the better. In man lymphatics have been demonstrated in organs in the fœtus when they could not be in the adult. Mature animals are better for the lymphatics of the reproductive organs; and for the pancreas an old man or animal is to be chosen.

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The writer wishes to express his great indebtedness to Professor Wilder for generous supplies of material for investigations in the comparative anatomy of the lymphatic system, for aid in purchasing costly works, and for hearty encouragement; to the library of the Surgeon-General's office for the loan of rare and valuable works of reference, and, finally, to the editor for encouragement and suggestions.

In preparing the article free use has been made of the larger works on physiology: Flint's treatise, Landois and Stirling; Milne Edwards, Leçons, etc. In human anatomy, Allen, Gray, and Quain in English; Sappey in French; Henle, Krause, Gegenbaur, and Hoffmann in German. The clinical remarks are especially complete and satisfactory in Allen; many very suggestive remarks are also made in Sappey's Atlas. In comparative anatomy the works of Owen, Gegenbaur, and Parker's translation of Wiedersheim, in English, and Milne-Edwards' Leçons, in French, are the most satisfactory. For the bibliography of the subject Milne-Edwards, Hoffmann, and Robin (see [5] below) are especially commendable, as is also the Index-Catalogue of the Surgeon-General's library. Specific references have been made to the following:

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Simon Henry Gage.

MULTIPLE NEURITIS is a disease of the peripheral nervous system, consisting of a more or less widespread, symmetrically distributed, degeneration in the nerves.

History.—This disease has only recently been generally recognized and diagnosticated. The symptoms which it presents had been for many years known and classified under the terms "alcoholic paralysis," "general spinal paralysis," "acute ascending myelitis," and had been erroneously referred to disease of the spinal cord. In 1864, Duménil,[1] of Rouen, recorded a case of paralysis, in which lesions of the nerves were found after death, and two years later he published another similar case.[2] But no notice was taken of these cases until 1876, when Eichhorst, of Berlin, recorded a case[3] of widespread disease of the peripheral nerves. This article of Eichhorst, and those of Joffroy,[4] in 1879, Leyden,[5] 1880, Lancereaux,[6] 1881, and Grainger Stewart,[7] 1881, attracted attention to the new disease, and many observations followed; so that, in 1884, Buzzard[8] was able, in the Harveian lectures, to present a clinical picture of the affection, and the writer, in 1887,[9] in the Middleton Goldsmith lectures, was able to collect a large number of facts bearing upon the pathology, etiology, and diagnosis of this disease.

Pathology.—The lesions in multiple neuritis are limited to the peripheral nerves, and are found to be more intense in the peripheral branches of those nerves than in the nerve-trunks. The condition found is one of degeneration, similar in all respects to the degeneration present after injury of a nerve (see Neuritis). The medullary sheath of the nerve-fibre is swollen, is divided into segments of semifluid consistency and fatty appearance. Its continuity is broken, and its insulating function suspended. This may be the only lesion in a very mild case, and regeneration may follow the degeneration. In more severe cases the degeneration proceeds, the medullary sheath is broken up into fine granules of fat or into a molecular débris, and is absorbed, and the axis cylinder is not only swollen, degenerated, and divided, but may also be changed into a granular mass and completely absorbed, so that an empty sheath of Schwann alone remains as a trace of the former nerve-fibre. In all the process the sheath of Schwann participates, its connective-tissue nuclei being swollen and segmented, and new nuclei appearing inside and outside of it. All these processes may be present simultaneously in various fibres of a nerve.

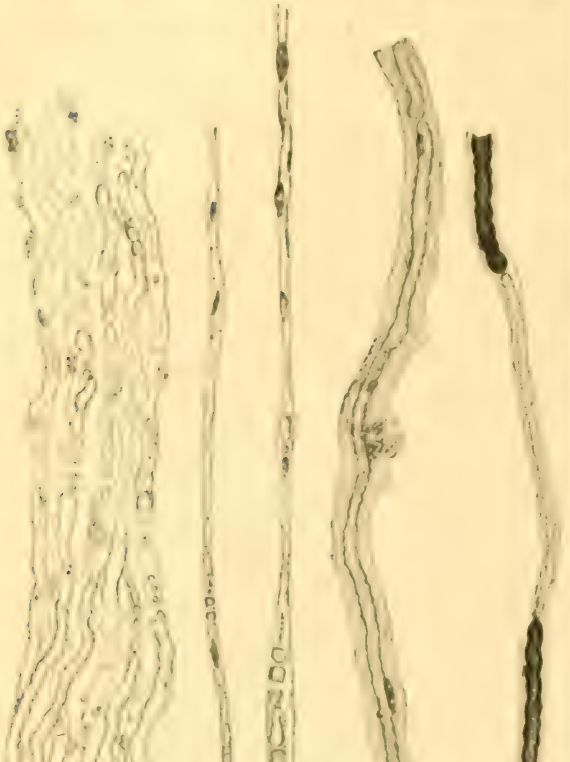

FIG. [illegible].—The Process of Degeneration and Regeneration going on in Normal Nerves. (After Mayer.) a, Segmentation of the myelin; b, remnants of sheath of Schwann [illegible]; c, sheath of Schwann, containing only nuclei and myelin; d, [illegible] in the sheath in process of regeneration; e, regeneration of a single segment after degeneration.

After the degeneration has proceeded for a time, regeneration begins. This takes place either by a development of new axis cylinders and medullary sheaths from nuclei in the old sheath of Schwann, as Neumann[1] holds, or by the growth of new axis cylinders outward from the undegenerated part of the old fibre into the old sheath, as Ranvier teaches.[1] This form of neuritis, in which the changes are especially marked in the nerve-fibres, is termed parenchymatous neuritis, in distinction from the second form, in which the connective-tissue elements take a more active part in the inflammation. Interstitial neuritis appears to have the same origin, and to occur under the same circumstances, as parenchymatous neuritis, but in it the endoneurium and perineurium take part in the process, and the increase of connective-tissue elements in the affected nerves is very noticeable. As far as is known, the process of regeneration does not differ in the two varieties. Lastly, a diffuse neuritis may occur in which both parenchyma and interstitial tissue are affected together.

Etiology.—There are many causes which produce multiple neuritis, and the cases may be classified according to the etiology.

There are, first, *cases due to toxic agents*, of which alcohol, lead, arsenic, bisulphide of carbon, and illuminating gas are the most active. All these agents produce widespread and serious effects upon the nervous system, but in many cases these effects are chiefly manifested in life, and at the post-mortem table, as changes in the peripheral nerves. The majority of cases of "alcoholic paralysis," "lead palsy," and "arsenical pseudotabes" are due to multiple neuritis.

There are, secondly, *cases due to infectious agents*, of which those producing diphtheria, variola, typhus, typhoid, malaria, and tuberculosis have been hitherto recognized. In the course of all these diseases, or as a sequel to them, multiple neuritis may develop, and its occurrence is too frequent to be accidental.

There are, thirdly, *cases occurring in epidemics* in many tropical countries, notably Brazil, India, Japan, Africa, and in the East and West Indies. Sporadic cases of this description developing among sailors on shipboard, occasionally find their way to our seaports. The disease is called kakke in Japan, beriberi in India and Brazil. It presents certain features which differ from those of the ordinary form. It has been ascribed to dampness, to a diet of rice or of fish, and to an infectious micro-organism.

There are, fourthly, *cases supposed to be due to exposure to cold* and dampness, and to *over-exertion*, or in which no cause is known.

In all these forms the clinical features of the disease are essentially the same, although different cases present a variety of combinations of symptoms.

Males are more liable than females. All ages after puberty are equally represented, excepting in diphtheritic cases, which occur chiefly in childhood.

SYMPTOMS.—The individual symptoms of multiple neuritis are very numerous.

The *sensory symptoms* are the earliest to appear and the last to pass away. In the majority of the cases of neuritis from whatever cause, numbness, tingling, or formication ushers in the disease. These forms of paræsthesia begin in the feet and hands and extend to the knees and elbows. They may be associated with burning, stretching, [illegible], or tearing sensations, which distress the patient especially during the onset. But all such sensations usu-

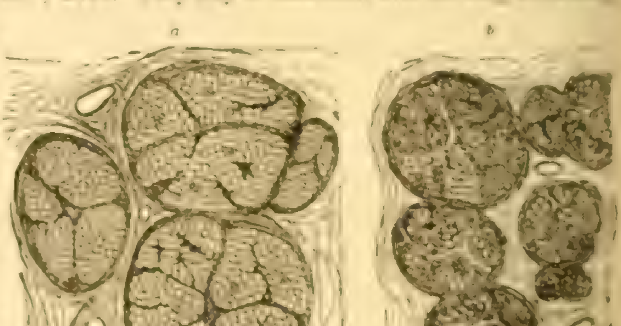

FIG. [illegible].—(After [illegible].) a, Section through normal nerve; b, section through degenerated nerve in a case of multiple neuritis, bundles reduced in size, individual fibres degenerated, their place being taken by débris.

ally subside as the affection reaches its height. Their recurrence, as the case goes on, may be regarded as a favorable symptom, however annoying, for they frequently precede recovery, and are among the last evidences of the disease to disappear. Pain is usually present as well as paræsthesiæ. It may occasionally be sharp in character, but is usually moderate and not continuous. At times it may be lancinating, and so severe as to necessitate the use of morphine. But it is rarely as distressing as in cases of locomotor ataxia. Tenderness in the nerves and muscles is a constant symptom. It may be so marked that the limbs cannot be moved or handled, and thus it may interfere with the application of electricity and massage. When the tenderness and pain are referred to the joints, as not infrequently occurs in the early stage of the disease, the case may be mistaken for one of acute articular rheumatism, and if the joints are swollen or the limbs œdematous, the difficulty of diagnosis is greatly increased.

In addition to these subjective feelings, some demonstrable disturbance of the various sensations is usually present. Hyperæsthesia to touch, and also to electricity, is not infrequently observed during the first few weeks. It is usually followed by some anæsthesia, although this rarely becomes complete. In some cases the loss of tactile sense is quite evident from the onset, either limited to the cutaneous distribution of some special nerve, in which case oddly shaped areas of insensibility will be found; or, as is most often the case, about uniformly distributed over the distal parts of the extremities. When the anæsthesia is at its height the patient has difficulty in locating a touch upon the limb, even though he feels it. The transmission of pain and temperature sensations is always delayed, but the impressions are usually felt quite acutely. The sense of pressure has been tested in only a few cases, and in those it was decidedly impaired. The muscular sense escapes being involved in some cases, but in others it is the most profoundly disturbed of all the senses. When it is involved, the inco-ordination and ataxia are well-marked symptoms, and, as already stated, some of the cases have been mistaken for locomotor ataxia, because of the predominance of the disturbance of muscular sense.

These sensory symptoms are usually limited to the forearms and hands, and to the legs and feet. In a few cases they have involved the entire extremities, and even the trunk; and one case of facial tingling, with anæsthesia, has been recorded.[12] The skin reflexes are usually preserved. In a very few cases the sensory symptoms have been entirely wanting.

The special senses are rarely affected in multiple neuritis. It is true that optic neuritis has occurred in a few cases, and in two cases hearing as well as sight has been affected. These cases prove that no nerve can be said to be exempt from implication in this disease, but the liability to affection seems to be slight in the case of the nerves of special sense.

The *motor symptoms* are as marked and as important as the sensory. Paralysis, beginning as simple weakness, with a feeling of fatigue on any exertion, gradually increases in severity, until at the height of the disease it becomes complete. It usually comes on rapidly, so that within two weeks the patient is helpless; but it may be less sudden, and not deprive him of the power of walking and of using his hands for two or three months. In a few cases a very acute onset is recorded, all the symptoms developing within three or four days. The distribution of the paralysis is not uniform at the outset. It may develop in the muscles supplied by a single nerve, and advance to others; it may begin in all the muscles of the legs, and then involve those of the forearms; it may commence in all four extremities at once. It is always more severe in the muscles which move the joints of the feet and hands, and the ankles and wrists. It rarely invades those which move the knees and elbows. When the disease is fully developed, all the muscles below the knees and elbows are much weakened, or totally paralyzed. In a few cases those of the thighs and arms are involved also, and occasionally the muscles of the trunk and those of respiration become affected and the patient dies. In some cases of multiple neuritis the motor cranial nerves become involved; those of the eye and of the face being most liable to invasion. It is only in fatal cases that the action of deglutition has been affected; and when the pneumogastric is invaded, and the heart becomes rapid and irregular, the prognosis is always grave. Spasms rarely occur.

The paralyzed muscles are relaxed, flabby, and atrophied; they may or may not lose their mechanical irritability, but their normal tone is always lost, and hence the so-called tendon reflexes are abolished. To the electric current their excitability is very rapidly and markedly changed; but the conditions which have been observed are quite various. Sometimes there is a simple diminution of excitability, and then a very strong faradic or galvanic current is needed to produce contractions. Frequently all faradic excitability is lost, and then the muscles react to a galvanic current only. In this condition it may require a very strong galvanic current to produce contraction, and this fact is quite pathognomonic of neuritis. For in anterior poliomyelitis, where the muscles respond to galvanism only, it does not require a strong current to cause a motion until some months after the invasion. The action of the different poles is not uniform. In many cases the contraction of the muscle when stimulated with the positive pole is greater than when stimulated with the negative pole, and the contractions may be sluggish. Then the reaction of degeneration is present. But in some cases the normal condition is found, and the negative pole produces stronger contractions than the positive pole. If the muscles that are not paralyzed be tested, the same electrical changes may often be discovered in them. A loss of faradic irritability and a marked decrease in the galvanic irritability of the muscle and nerve are, therefore, important symptoms of multiple neuritis. And as the disease goes on to recovery a gradual increase in the galvanic irritability occurs, a fact which is often of much aid in prognosis, if careful measurements of the strength of current used be made by the galvanometer.

As a result and accompaniment of the paralysis, *abnormal positions* are assumed by the limbs. The dropped wrist and dropped foot are quite characteristic of multiple neuritis. But other deformities may be present. In a few cases there have been extreme contractures of all the extremities in flexed position. And not infrequently the appearance of the claw-shaped hand, and some one of the various forms of talipes, indicates a serious shortening of one set of muscles, and corresponding weakness of its opponents. These deformities usually subside as the power returns, or if they do not they can be corrected by proper manipulation and by apparatus. In a few cases it has been necessary to resort to tenotomy, but a permanent deformity has not been recorded.

The *vaso-motor and trophic symptoms* are less constant than those already described. They are present in the epidemic form in all cases, and are especially severe. In some cases marked œdema has been an early and a permanent symptom. This may develop in the feet and hands, or may appear about the joints. It usually is temporary. The circulation is not impaired any more than is customary in a limb whose muscles are inactive, and coldness and cyanosis are rarely sufficient to attract attention. Sometimes profuse perspiration is a noticeable symptom, being limited to the paralyzed parts. It may be offensive, and by its evaporation always causes a complaint of coldness. In other cases glossy skin makes its appearance early, and remains until regeneration of the nerves begins. Its disappearance in one of my own cases was the first sign of recovery in the lower extremities. Other forms of trophic disturbance are rarely met with in multiple neuritis. And this is quite remarkable in view of the fact that it has been the tendency of late to refer such trophic affections as ulcerations, bed-sores, gangrene, pemphigus, and various eruptions to lesions of the nerves. It is true that inflammations of the joints, resembling those appearing in acute rheumatism, sometimes occur at the onset of neuritis, but as they disappear quickly, while other symptoms remain, it is improbable that they are to be traced to the changes in the nerves. They may be due to the infectious agent, or to the same toxic cause which sets up the neuritis, or they may be evidence of an attack of acute articular rheumatism, which is in turn followed by neuritis; but they cannot be described as typical symptoms of the disease, otherwise they would be more constant in their occurrence and more permanent in their duration.

One feature of alcoholic paralysis remains to be noticed, viz., the cerebral symptoms. These are hardly ever wanting. There is at first the excitement rising to the degree of active delirium, with illusions and hallucinations of the various senses; there is the insomnia, which so much exhausts the patient if it is not controlled; there is the loss of memory, especially of recent occurrences; and the lack of power of attention or concentration, which prevents intelligent conversation. The indifference to bodily wants may be so great as to lead to uncleanliness, and since paralysis of the sphincter is the rare exception, incontinence is usually to be ascribed to the mental state. It is useless to attempt to get any reliable history of their illness from these patients. Their statements are unintelligible or unreliable. And here it may be well to notice a symptom first remarked by Strümpell. These patients will relate occurrences as having happened recently, with much elaboration of detail, when, as a fact, the story is entirely a product of their imagination. Thus one patient of my own, who had been confined to bed for many days, told me one afternoon that she had been out to see an eminent gynecologist during the morning; had gone to his office and waited for him several hours; had seen other patients there; and finally had been told by the doctor's brother that he would not return in time to see her, so she had come home again. And this was all related in apparent good faith, so that I have no doubt that she believed that what she said had occurred. With the possibility of such delusions in view, it is evident that the statements of these patients cannot be accepted regarding anything, especially as to their own history.

One patient, who was admitted to Bellevue Hospital during my service there, told me a different history of her case every day for a week, and it was only by interviewing her friends that the correct account was obtained.

A negative symptom of some importance is the absence of any interference with the automatic acts controlled by the sphincters, in the majority of cases.

The onset is usually sudden, and is sometimes, in toxic and septicæmic cases, accompanied by a marked febrile movement, with chills and temperature of 102° to 104.5° F. The fever may persist for several days, but usually subsides spontaneously, and does not recur. In a few cases there has been a constant elevation of temperature from one-half a degree to one degree and a half above the normal; and an increase in the rapidity of the pulse throughout the disease has been noticed. A pulse of ninety need give no alarm, but if it rises up to one hundred and forty, and becomes irregular, there is reason to believe that the disease has attacked the vagus nerve, and then the prognosis becomes serious, though not by any means hopeless.

The duration of the disease varies considerably in different cases. An average of twenty-five cases gives seven months as the probable time required for complete recovery. But in these cases the duration varied from two months in the most favorable to sixteen months in the most refractory.

Diagnosis.—It is by reference to the etiology and to the course of the case, as well as to the combination of symptoms present, that the diagnosis of multiple neuritis must be reached. The most important diagnostic symptom is tenderness along the course of the peripheral branches of the nerves and in the muscles. The cases most liable to be mistaken for multiple neuritis are anterior poliomyelitis, locomotor ataxia, and diffuse central myelitis. The following tables present the differences usually found:

ANTERIOR POLIOMYELITIS.	MULTIPLE NEURITIS.
Sudden onset with fever and development of paralysis in one day, [illegible] muscles not tender.	[illegible] are very tender.
Sensory symptoms not present, [illegible]	Sensory symptoms are common, and muscles and nerves tender, [illegible]

Paralysis, atrophy, reaction of degeneration, coldness of the limbs, loss of tendon reflexes, preservation of bladder control, are common to both diseases.

LOCOMOTOR ATAXIA.	MULTIPLE NEURITIS.
Pains are paroxysmal, [illegible]	Paræsthesia is more constant than pain.
Nerves are not tender.	Pain is produced by pressure on nerves.
Ataxia develops slowly and after a period of pain.	Ataxia is an early symptom, develops rapidly, and may exist without pain.
Anæsthesia and analgesia in patches.	Anæsthesia is [illegible] total.
No marked paralysis or atrophy.	Paralysis with atrophy.
No change in electric reactions.	Changes in electric reactions.
Argyll-Robertson pupil present.	Pupils react normally.

There are very few symptoms of diffuse myelitis which are not found in cases of neuritis. But cases of diffuse myelitis of the type of Duchenne—paralysie générale spinale subaiguë ascendante—are very rare, and, indeed, by Leyden it has been affirmed that all such cases are multiple neuritis. Other authorities dispute this assertion and leave us to establish points of difference. These are as follows: In neuritis affections of the functions of micturition and defecation do not occur. Girdle sensation is very rarely mentioned as a symptom; bed-sores and cystitis have not been observed. The advance of the paralysis is rarely from the legs to the thighs and trunk, and then to the arms; it is usually from the legs to the forearms, the trunk and thighs escaping, and, as a rule, the distal portions only of the extremities are paralyzed. If the muscles of the abdomen and respiration are involved, it is only in rapidly fatal cases. In neuritis there is usually some ataxia, and loss of muscular sense is quite evident; while in some, at least, of the cases of myelitis of Duchenne, there were no sensory symptoms at all. Finally, the tenderness of muscles and nerves, and the absence of tenderness to pressure or to heat in the spine, would decide in favor of neuritis. The diagnosis from meningitis of the cord, from tumors or hemorrhages into the cord, or from general paralysis of the insane, would rarely present any difficulty to one who was familiar with the symptoms in these affections, and who knew the prominent features of multiple neuritis.

There are certain common types of the disease, a familiarity with which may aid in the diagnosis. If a patient known to be alcoholic complains for a time of tremor and muscular weakness, and then is suddenly paralyzed in the legs and arms, develops fever, becomes delirious, and shows great tenderness of the limbs and rapid loss of faradic electric reaction in the muscles, the diagnosis of multiple neuritis can be made. If a patient who has been taking arsenic medicinally for some time, begins to complain of paræsthesia, clumsiness and fatigue, and soon shows a marked ataxia in hands and feet, with tenderness along the nerves, some atrophy in the weak muscles, and a change in their electric reactions, the diagnosis of multiple neuritis can be made. Lead palsy is easily recognized. Diphtheritic paralysis is usually limited to the muscles of the pharynx or of the eyeballs, but the sudden onset of marked ataxia without a preceding stage of pain after diphtheria warrants the diagnosis of neuritis. If a tuberculous individual suddenly develops pain and tenderness and weakness in both arms or both legs, and this is followed by paralysis and atrophy in a few symmetrically situated muscles, the diagnosis of multiple neuritis can be made. And lastly, if any one of these clinical pictures is presented by a patient who has been exposed to cold or to wet, or has overstrained himself severely, and a careful examination fails to reveal the characteristic symptoms of general diffuse myelitis, while the limbs are very tender to pressure, multiple neuritis may be suspected.

The cases of *beriberi* are divided into two general classes, according to their severity.

There are, first, slight cases, in which the onset is gradual, being usually preceded by a little fever, coryza, and conjunctivitis, which cease when the actual symptoms commence. The patient first notices a weak and heavy feeling in his legs, and finds that he tires so easily that he cannot walk as much as usual. The tired feeling is soon associated with numbness and pain in the legs, and with a slight œdematous swelling. Then, if not before, palpitation of the heart, oppression and weight in the epigastrium, loss of appetite, and general malaise are felt, and the patient finds it necessary to apply for treatment. An examination then shows some diminution of power in the feet and legs, and also in the hands, with loss of tendon reflexes, and much tenderness in the muscles, which show a diminished electric excitability. There is never any ataxia, though the patient sways when his eyes are closed. There is discovered a slight degree of anæsthesia, of irregular distribution, chiefly in the legs and in the radial-nerve region on the forearms. Though the patients look pale, it is usually impossible to find anæmia by examination of the blood. The circulation in the extremities is sluggish. The heart is irregular and rather rapid, and the œdema of the extremities indicates a failure of its power. Dr. Wallace Taylor[13] finds that a sphygmographic tracing is characterized by a sudden high upstroke in ventricular systole, by a precipitous descent from the apex of the percussion-wave, and by dicrotism. Beyond this point these cases, which make up the majority, do not advance. They usually recover in a few days, or at most a month; although a few become chronic and require several months before the cure is complete.

There are, secondly, severe cases. These may present three different types. There is the atrophic or dry type, in which, after an onset similar in nature to that in the slight cases, but much more rapid, the weakness develops into a true paralysis, associated with marked wasting of the muscles and reaction of degeneration, with great diminution of galvanic excitability. Within a week the patient has to go to bed, and then the paralysis soon spreads from the legs to the arms, and may involve the trunk and even the face. The entire muscular system wastes away till the patient is a mere skeleton. In addition to the motor symptoms there is great sensory disturbance. The suffering from pain, paræsthesiæ, and general muscular tenderness is extreme, and the patient lies totally helpless, and unable to tolerate the lightest touch. The skin may be glossy. There is usually some anæsthesia, but it is never complete, although it may involve the entire body. The temperature sense is seldom affected. Pain may be delayed in transmission. There are no gastric symptoms, and no œdema. Some cases prove fatal from general exhaustion, or intercurrent disease, but the majority recover after a convalescence which lasts a year or more, during which the muscular system is rebuilt.

There is, secondly, the hydropic or wet type. In these heart-failure appears early, and is associated with a marked decrease of arterial tension and much œdema of the entire body, effusion into the cavities being added to that beneath the integument. The swelling of the œdematous parts conceals the atrophy which is going on in the muscles, but this is indicated by the paralysis, which is as severe as in the preceding form, and it becomes evident during recovery when the œdema has subsided.

There is, thirdly, the acute pernicious type. In this all the symptoms of the two former types appear in rapid succession, and, in addition, gastro-intestinal symptoms and a suppression of urine combine to make the condition an alarming one. Effusions into the pleura and pericardium appear early. The pulse becomes small and irregular, and cyanosis indicates the heart-failure which precedes death.

Prognosis.—The prognosis of multiple neuritis is good, excepting in severe alcoholic cases, and in the very severe forms of beriberi just described. The progress of the recovery may be slow, in some cases two years may elapse before it is complete, but seven months may be considered the average duration, and slight cases may get well in three months.

Treatment.—The majority of the cases being toxic in origin, the most important indication is to remove the cause. Total abstinence from alcohol is necessary for at least two years after recovery to prevent a relapse. Lead and other poisons must be eliminated from the system. Such hygienic measures as may be used to counteract influences of an infectious kind must be employed. The direct treatment of the disease is aided by the spontaneous tendency to recover in a person whose constitution is sound, and whose strength is maintained by general tonic treatment. It is possible to hasten the process of regeneration by the use of full, nutritious, and especially fatty diet, including cream and cod liver oil; and by the administration of strychnine, phosphorus, iron, and arsenic, no one remedy being continued for more than three weeks at a time. The use of warm and cold douches to the paralyzed limbs, of skilful massage when the tenderness has sufficiently subsided, and of mild (10 ma.) constant stabile galvanic currents along the limbs, probably aids the regeneration by stimulating the circulation and increasing metamorphosis of tissue. The daily use of the interrupted galvanic current to the muscles, of sufficient strength to produce contraction in them, gives them proper exercise to maintain their tone. Rest is enforced by nature for some time, but moderate exercise is indicated during recovery, but should not be carried to the point of fatigue. *M. Allen Starr.*

[1] Duménil: Gaz. Hebdom., 1864, p. 203. [2] Ibid., 1866. No. 4.

[3] Eichhorst: Virchow's Archiv, Bd. 69, p. 265.

[4] Joffroy: Arch. de Phys. Norm. et Pathol., 1879, p. 172.

[5] Leyden: Charité Annalen, 1880, and Zeitsch. f. Klin. Med., 1880.

[6] Lancereaux: Gaz. Hebdom. de Méd., 1881, p. 120.

[7] Grainger Stewart: Edinburgh Medical Journal, April, 1881.

[8] Buzzard: Harveian Lectures, Lancet, November and December, 1885.

[9] Starr: Middleton Goldsmith Lectures for 1887, Medical Record, February, 1887, where a complete bibliography to date is to be found.

[10] Neumann: Arch. f. Mikro. Anat., xviii.

[11] Ranvier: Leçons sur l'Histologie du Syst. Nerv., tome ii., p. 42.

[12] Lowenfeld: Neurol. Centralblatt, 1885, No. 7.

[13] Wallace Taylor: Kakké. Tokio, Japan, 1887.

[14] Byrom Bramwell: American Journal of the Medical Sciences, June, 1888.

MUSCULAR RHEUMATISM is an indefinite and unscientific term, applied to certain painful states of the voluntary muscles. That it is a misnomer in the great majority of cases, at least, there can be no doubt, for the fact is established that the essential pathological conditions, and many of the important symptoms pertaining to rheumatism, are wanting in this affection.

The term myalgia has been proposed as a substitute, and as a proper designation of most of the disorders usually grouped as muscular rheumatism. Myalgia signifies merely muscular pain, and suggests no erroneous theory as to its cause and nature. Sensation, however, is not an endowment of muscular fibre, and, in its last analysis, this symptom must be referred, not to the muscular tissue proper, but to the sensory nervous filaments supplied to the part affected.

Whether the prime cause of the painful sensations conveyed through the nerves resides in the ultimate nervous fibrils themselves, in the neurilemma, in the muscular fibres, or in their enveloping sheaths, must be left for future researches to determine. But with the light before us the pain appears to be neuralgic—neuralgia which does not involve the nervous trunks or their larger branches, and, consequently, which does not follow their courses, and which presents no painful points—the *points douloureux* of Valleix; a neuralgia affecting possibly only the primitive nerve-fibrils or the smaller fasciculi, and the tissues, perhaps, in intimate relations with them, and therefore diffused, and more or less uniformly distributed through a single muscle or a group of muscles.

Morbid changes in the affected muscles are rarely found. The symptoms have been ascribed to hyperæmia, to slight effusion or exudation, and to subacute infilamentation of the tissues. The gross features of inflammation are not present, but this fact does not prove that inflammatory action in some of the tissues composing the muscular fasciculus never exists. On the contrary, there is reason to believe that in many of these cases slight inflammatory processes or changes do occur, and it is not unlikely that with a growth of pathological knowledge it may be shown that several affections, dependent upon different morbid states, are included in the general term muscular rheumatism. At present it must be admitted that muscular rheumatism has no settled or uniform anatomical character.

The affection is of frequent occurrence. It may be acute or chronic. The advent of an attack may be gradual, commencing as a dull pain in a muscle or a group of muscles, and becoming more and more severe; or it may develop suddenly, and be violent from the outset.

Pain is always the prominent, and it may be the only, appreciable symptom. The character of the pain varies in different individuals, or in different attacks in the same individual. It may be sharp and excruciating, cramp-like and tearing, or throbbing and continued. The pain may be constant though slight, and intensified to an extreme degree by contraction of the affected muscle; or it may cease when the muscle is absolutely quiet, only to be aroused upon movement or by involuntary contraction of the muscle.

The pain as a rule remains fixed and does not shift from the point of original attack, though it sometimes changes from one muscle to another. There are no external visible signs of the local trouble; no heat, redness, or swelling, and usually little or no tenderness. Where tenderness on pressure exists, it is generally moderate in degree, and is diffused over a whole muscle or over a set of muscles. There is but little if any constitutional derangement, and usually no febrile disturbance in uncomplicated cases. The pulse is but slightly or not at all affected. The urine is normal. Cardiac complications do not occur.

The acute form lasts for from a few days to a week, and gradually subsides. Sometimes the acute symptoms recede, and the attack lingers in a subacute or chronic form indefinitely. In the chronic form exacerbations provoked by slight exciting causes are commonly experienced. Age appears to influence the localization of an attack. The muscles of the neck are prone to suffer in younger subjects, while the muscles of the back and limbs are more liable to invasion in older persons. The muscles affected for a considerable period of time, or which sustain frequently repeated attacks at short intervals, are apt to become atrophied.

Attacks of muscular rheumatism are usually attributed to exposure to cold, especially to a cold and damp atmosphere after severe fatigue or muscular strain. Debility and overwork and defective nutrition, either general or local, invite attacks. The rheumatic and gouty diatheses have been regarded, and are still considered by some observers, as predisposing causes. The direct relation of cause and effect is denied by others, who affirm that localized muscular pain is of no more frequent occurrence in the subjects of acute articular rheumatism and of gout than in persons who do not suffer from these diseases, which act as predisposing causes only by inducing a state of general debility. Muscular rheumatism frequently occurs during the course of wasting diseases, and during convalescence from exhausting and severe illness. Any condition which impoverishes the blood, and which diminishes the resisting capacity of the system, may be regarded as holding a causative relation to this affection.

By close attention to the history of a given case, to the physical signs and to the symptoms, and by a process of exclusion, a correct diagnosis may readily be reached.

Muscular rheumatism is most likely to be confounded with inflammatory diseases of the thoracic viscera, with structural disease of the spinal cord, with spinal meningitis, spinal caries, deep-seated inflammation, lumbar abscess, certain functional disorders connected with the spinal cord or spinal nerves and with the genital organs, with sciatica, coxalgia, perinephritis, renal calculus, abdominal aneurism, and with the onset of some acute diseases characterized by lumbar pain.

The prognosis in acute cases, under favorable circumstances, is good. It is always good as regards complications and serious results. Chronic cases are apt to prove obstinate and rebellious to treatment. They are difficult to cure, and manifest a tendency to frequent relapses. Success in eliminating the disorder is influenced largely by the physical condition, by the occupation, and by the hygienic surroundings of the patient.

Relief of pain, rest of the affected muscle or muscles, and general or local invigorating measures, constitute the important indications for treatment.

Rest alone will often suffice to relieve the pain. If, notwithstanding complete relaxation of the sensitive muscles, pain continues, anodynes may be demanded. Opium, in some form, may be prescribed with confidence. It may be advantageously combined with belladonna or with atropine. Quinine, salicylate of soda, and salol are used with advantage; acetate of potassium or acetate of ammonium, the iodide of potassium, and colchicum are commended. Stimulating or anodyne liniments, dry or moist warmth, dry cups, and blisters are serviceable. Galvanism and the ether spray to the part sometimes act like magic. Local depletion is not indicated. Cathartics may be required. Faradic electricity is at times useful in stimulating the nutrition of wasted muscles after the pain and tenderness have been relieved. In severe cases rest, even rest in bed, is demanded by the disturbing effect upon the patient of excessively painful muscular movements. Enforced quietude of certain muscles may be secured by the judicious application of bandages or of adhesive strips.

Invigorating measures of treatment have reference mainly to the regulation of exercise, to a pure atmosphere, to suitable clothing, to a generous regimen, and to appropriate general and digestive tonics.

James E. Reed.

OCEAN SPRINGS. *Location and Post-office*, Ocean Springs, Jackson County, Miss.

Access.—By the Louisville & New Orleans Line of the Louisville & Nashville Railroad.

Analysis (J. L. Smith).—One pint contains:

	Grains.
Chloride of potassium	Trace
Chloride of sodium	5.471
Chloride of calcium	0.486
Chloride of magnesium	0.621
Protoxide of iron	0.589
Iodine	Trace
Alumina	Trace
Organic matter	Trace
Total	7.166

Gases.	Cubic in.
Carbonic acid	1.32
Sulphuretted hydrogen	0.31

Therapeutic Properties.—This water is a mild saline-chalybeate, containing also sulphuretted hydrogen. This rather unusual combination renders it effective in the treatment of persistent skin and scrofulous diseases.

These springs are situated fifty-seven miles west of Mobile, and eighty-four miles east of New Orleans on the railroad connecting the two cities, and are a favorite resort of the citizens thereof. They are about half a mile from the beach, from which fact is derived the name. *G. B. F.*

PERFORATING ULCER OF THE FOOT. As described by Treves this ulcer appears at a spot on the sole of the foot upon which pressure bears, usually over the metatarso-phalangeal joint of the great toe or over the corresponding joint of the little, or on the pulp of the great toe. The skin thickens, and from the pressure that it exercises upon the soft parts beneath it some inflammation of an insidious type follows. Suppuration then appears beneath the corn, and spreading in the direction of least resistance, advances into the soft parts of the sole, moving toward the bone. Possibly the column of soft parts compressed beneath the corn, and the bone beneath which it lies, may perish almost *en masse*, as would appear to be the case with the tissues in acute bed-sores of spinal origin. A sinus forms leading to the bone, while around the margin of this opening the epithelium continues to heap itself up. The sore appears to be set upon a mound of hardened, thickened integument, and it thus happens that the depth of the ulcer or the length of the sinus is greatly increased.

Perforating ulcer of the foot is generally solitary, but may be multiple. It is occasionally hereditary. While a corn may be in many cases the exciting cause, a central or peripheral nerve-lesion is now generally regarded as the predisposing cause. Similar ulcers are met with in anæsthetic leprosy, in locomotor ataxia, and in paralyzed limbs. The sensory nerve-fibres distributed to the affected foot in perforating ulcer are generally diseased.

Perforating ulcer is treated by Treves as follows: The patient is put to bed and the foot is kept continually poulticed with linseed meal. This causes the epithelium to soften and swell up, so that at the end of twenty-four hours the ring around the sore appears as a very prominent, softish, white mound. All this redundant epidermis is then shaved away with a scalpel, and the poultice is reapplied. At the end of another twenty-four hours the deeper layers of epithelium, that were not affected by the first poulticing, have become swollen and prominent. They are in turn cut away. The poultice is again applied and the scalpel used day by day, until the whole of the epidermic mass has been removed. This will be accomplished at the end of from ten to fourteen days. By this time the skin about the ulcer will, as a result of the continued poulticing, have peeled off in a thick white layer, and around the sore will be nothing but thin, fresh pink epidermis, looking active and healthy. The ulcer, in the meantime, will be found to have become clean, and in consequence of the loss of its cutaneous boundary, it will appear less deep. The poultices are now discontinued, and to the sore is applied a paste, of the consistency of thick cream, composed of salicylic acid and glycerine, to which is added some carbolic acid, in the proportion of ten minims to the ounce. This ulcer soon heals, and when the patient gets up he is instructed to wear over the part a thick pad of felt plaster with a hole in its centre that corresponds to the scar of the recent sore. The plaster should be always worn.

Unfortunately this treatment is often unsuccessful, and it is necessarily so if the bone is diseased. In that case the carious bone must be removed, or the toe or the foot must be amputated; but even then the disease is apt to return in neighboring parts. As a last resort, Messrs. Savory and Butlin recommend the use of an artificial leg attached to the bent knee, so that the foot may be carried without having to take any part in supporting the weight of the body (McCall Anderson).

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Savory and Butlin: Med. Chir. Trans., Second Ser., vol. xliv., p. 373 *et seq.*, 1879.

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Arthur Van Harlingen.

PHARYNGEAL BURSA, NEUROSES OF THE. That the nasal pharynx is exquisitely sensitive to reflex-producing impressions is a fact which has been known for some time, and the older medical literature contains isolated examples of neurotic phenomena of various kinds emanating from pathological conditions of this region. These reflex neuroses of the nasal pharynx were, however, almost unknown, except to special workers in this field, until the publication of a brochure by Dr. Tornwaldt,[1] of Dantzig, in which prominent attention was drawn to the subject, and which invested the so-called bursa pharyngea with a pathological importance hitherto unrecognized and undescribed.

According to Tornwaldt, this bursa is a constant integral part of the rhinoscopic picture, and can always be recognized, sometimes as a furrow, sometimes as a blind cul-de-sac, directly in the middle line in the centre of a curve drawn from the upper edge of the posterior nares to the atlas. This sac is the frequent seat of various pathological processes—hyperæmia, cystic formations, hypersecretion, and simple and purulent inflammation; and these often lead to reflex disturbances, such as asthma, cough, nasal polypi, various ear troubles, neuralgia, inflammatory conditions of the naso-bronchial tract, etc. He furthermore maintains the proposition that naso-pharyngeal catarrh has its starting-point, in very many cases, in a localized pharyngeal bursitis, and that its cure is possible only after destruction of the bursa itself. His treatment accordingly consists in the obliteration of the bursa by means of nitrate of silver, following insufflations of this agent (1 to 10) with the application of the fused stick directly to the sac. Tornwaldt's hasty enthusiasm carries him to the startling statement that, of 892 cases of naso-pharyngeal disease examined by him, 202 were primary affections of the pharyngeal bursa.

There are many objections which may be urged against the theory of Tornwaldt. In the first place, the very constancy and existence of the pharyngeal bursa is a subject of dispute among distinguished anatomists, and besides, according to my experience, the appearances described by Tornwaldt are by no means constant in the rhinoscopic image.

In the second place, when we consider the changes which take place in the pharyngeal vault during the different stages of inflammatory affections of the nasal pharynx—the frequent formation of cysts of varying shape and contents, the formation of depressions, furrows, and other conditions of the pharyngeal tonsil (see for fuller account the article on Chronic Naso-pharyngeal Catarrh, Vol. V. of this HANDBOOK, pp. 207–208), it will be readily understood how easily mistakes in diagnosis may occur, or how difficult it often is to differentiate between well-recognized appearances in the pathological anatomy of post-nasal inflammation and the theoretical primary bursitis of Tornwaldt. That such errors have indeed been committed, is evident from some of the recent literature on the subject.

It is highly improbable, nor are there any just grounds for belief, that an organ of such comparatively trifling anatomical and physiological importance should be vested with the peculiar privileges assigned to it by the followers of Tornwaldt. Since I became aware of Tornwaldt's researches, I have searched in vain for what might be unequivocally termed a primary pharyngeal bursitis. When the bursa has been involved, it has invariably been so in connection with well-marked and far-advanced naso-pharyngeal disease; so that, from the standpoint of my own clinical experience, I am unable as yet to confirm the observations of Tornwaldt. Naso-pharyngeal disease is the most common affection of this climate, and the innuendo of Carroll Morgan, that the postulate of Tornwaldt regarding the great frequency of primary disease of the bursa, living, as he does, in a city of small population, has not been confirmed by the vast majority of specialists residing in large cities, and commanding an immense amount of clinical material, may possibly carry with it considerable force.[2]

While, then, Tornwaldt's observations must, for the present, be taken with a considerable amount of reservation, they have, at least, directed prominent attention to a field of naso-pharyngeal pathology of exceedingly great interest and importance. From them we may learn the lesson that, in order to dissipate certain inveterate naso-pharyngeal affections, we must not rely on astringents, alteratives, *et id omne genus*, but we must *destroy* the source of the discharge.

My own observations concerning this class of naso-pharyngeal neuroses, may be briefly summed up in the following propositions:

1. The nasal pharynx is, in quite a large proportion of individuals, exceedingly sensitive to reflex-producing stimulation.

2. The areas chiefly involved are the posterior portions of the turbinated erectile tissue and various points along the upper and posterior portions of the nasopharynx.

3. In consequence of this extreme sensitiveness a local pathological process, which in many persons would give rise to no reflex vaso-vascular changes, may awaken a host of neurotic phenomena, referable not only to the region primarily involved, but also to other and even remote regions of the body. These may include cough, asthma, and various neuralgic affections, or the local structural lesion may be the starting point of the various sympathetic affections of the respiratory tract.

4. That these naso-pharyngeal neuroses are explicable on the same general principles as those laid down in the article on Neuroses of the Nose, in Vol. V. of this Handbook, and the pathology of the nasal and post-nasal affections is, therefore, one and the same.

5. That the treatment should be carried out according to the general directions laid down in the article just mentioned.

6. That when the morbid process originates in the pharyngeal tonsil, attention should not be directed to the bursa alone, but an endeavor should be made to extirpate the tonsil, as far as possible, in its entirety.

7. That, while a favorable prognosis cannot be safely predicted by treatment of the bursa alone, extirpation of the pharyngeal tonsil often offers the most favorable prospect in long-standing cases of post-nasal inflammation. *John N. Mackenzie.*

[1] Ueber die Bedeutung der Bursa Pharyngea, etc. Wiesbaden, 1885.
[2] Maryland Medical Journal, March 19, 1887.

PLACENTITIS. DEFINITION.—This term is applied to inflammation of the placental tissue, which may be acute, terminating in suppuration, or chronic, resulting in the formation of fibrous or cicatricial tissue. It may, according to Simpson, be confined to the cotyledons or to the membranes. It should be stated that authorities are at variance regarding the true character of the morbid changes, some considering them as ordinary retrograde processes and not of inflammatory origin.

HISTORY.—The first mention of this condition is contained in Guillemeau's "Œuvres de Chirurgie." Brachet, in 1828, first clearly described "hepatization" of the placenta, and reported four cases. Stratford and Dance (1829) have also reported cases. Simpson's elaborate paper on this subject was published in the *Edinburgh Medical Journal* for January, 1836. Geoffrey wrote concerning placentitis in 1858, and Joulin in 1867, Millet having previously (1861) published a thesis in which he expressed doubt concerning its existence, in which opinion he was upheld by Charpentier.[1] We are indebted to Whittaker[2] for a lucid presentation of the existing knowledge concerning this affection. Maréchal[3] has given a *résumé* of the recent French views. He states that not over twenty authentic cases have been recorded.

ETIOLOGY.—The causes of this condition are very obscure. Brachet attributed some cases to mental shock, or to a blow or fall during pregnancy. He also traced it to a pre-existing metritis and endometritis. The latter explanation was accepted by Simpson, and more recently by Schroeder. Some confusion has arisen from the tendency to include syphilitic changes in the placenta under the head of true placentitis. The former are essentially chronic, while the writers who originally described placentitis evidently limited this term to an acute inflammatory process, which might subsequently become chronic. Moreover, by reference to the supposed causes of the latter condition, it will be evident that it is an acute process that develops in a placenta previously healthy, while the changes due to syphilis may be coincident with the origin and growth of the placental tissue. The anatomical [illegible] is less clearly defined.

PATHOLOGY.—Brachet, in describing the anatomical changes in placentitis, seems to institute a close comparison between it and lobar pneumonia, since he distinguishes three stages, viz., congestion, red and gray hepatization, and suppuration ([illegible]). Robin, on the other hand, says that "what has been taken for infiltration of the placenta is nothing else than a condition of transformation of blood-clots at various periods." "What has been regarded as pus," he continues, "is only fibrin in the course of disorganization; and in those cases in which true pus has been found, the pus did not come from the placenta, but from an infiltration of the tissue of the uterine vessels and an accidental depositing in the tissue of the placenta." The absence of capillaries in the maternal portion of the placenta, as Whittaker properly objects, renders it impossible for us to conceive of the existence of a true round-cell infiltration, according to the modern theory of Cohnheim. In describing the pathological anatomy of placentitis, therefore, we follow the teaching of the earlier writers, especially Simpson, which is open to serious doubt on the score of accuracy. The disease may begin in one lobe of the placenta or in several simultaneously. It may originate in, and be confined to, the placenta (decidua serotina), or may be secondary to endometritis; the uterus is rarely affected secondarily.

Stage of Congestion.—The vessels of the affected portions are engorged with blood, and the placenta becomes swollen and of a darker hue than normal. According to Simpson, in simple congestion the entire placenta is hyperæmic and swollen and not merely isolated lobes as in the condition now referred to. Vessels may rupture in consequence of increased blood pressure, giving rise to hæmorrhages on the fœtal surface of the placenta.

Stage of Hepatization.—The parenchyma, in consequence of infiltration with blood and serum, becomes solid and inelastic, and has a deep red color. On section a quantity of sanguineous fluid escapes. Later, the diseased tissue becomes more fibrinous, has a grayish-yellow color, and is much more dry than before. The membranes are at the same time thickened, and may become adherent to the uterus or to the fœtus. The stage of "gray hepatization," as Simpson calls this change, is doubtless simply fatty degeneration, with or without the accompanying formation of new connective tissue.

Stage of Suppuration.—This mode of termination is rare, only ten cases having been reported in which circumscribed abscesses developed. Brachet describes one that involved three-fourths (¾) of the placenta, while O'Farrell reports a case in which an abscess containing twelve ounces ([illegible]) of stinking pus developed in the placenta after a blow upon the abdomen. The patient was delivered of a macerated fœtus, and made a good recovery. Cruveilhier[4] mentions cases in which there was general purulent infiltration of the placenta, the fœtal surface being covered with plastic exudation. Dance[5] once observed a layer of pus between the uterus and the placenta, which was apparently derived from the latter. Breschet[6] reports two similar cases. These abscesses are said to have no pyogenic membrane. It must be evident to the reader that in most of these cases there is a strong probability that the pus was derived from the inflamed endometrium, and that its occurrence in the placenta was accidental.

In short, as before stated, the three stages just described are so clearly defined as to awaken the suspicion that they have no existence except in the imaginations of observers who saw, but misinterpreted, certain appearances which are readily explained in the light of modern knowledge. What really occurs is probably congestion, effusion of blood between and on the surface of the cotyledons, and the usual retrograde changes in the effusion. Changes occurring in the adventitia of the vessels (fibrous thickening) result in obstruction of their lumina and fatty degeneration or fibrous atrophy. Collateral hyperæmia in unaffected portions of the placenta may lead to fresh ruptures and extravasations. In syphilitic placentitis, in addition to the vascular changes, the villi are thickened and their cells undergo cloudy swelling, while gummata are scattered about between the cotyledons.

RESULTS.—If the inflammatory process is circumscribed, the unaffected portion of the placenta may suffice to nourish the fœtus, which reaches maturity before being expelled. The hæmorrhages on the surface of the placenta may be the direct cause of abortion; or, in consequence of the obstruction to the circulation through the placental vessels following fibrous atrophy of the placenta, the fœtus may be deprived of nourishment, and will then be expelled prematurely. After delivery portions of the diseased placenta may be retained, either because it is so softened as to tear readily, or in consequence of the adhesions between the placenta and the wall of the uterus.

Symptoms.—These are so indefinite that even Simpson lays little stress on them. The patient usually complains of severe pain in the uterus and loins. In one instance the woman had chills and elevation of temperature in the middle of pregnancy, accompanied by irregular discharges of blood from the uterus. *H. C. Coe.*

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[1] Maladies du Placenta, 1869.

[2] Prize Essay on The Morbid Anatomy of the Placenta, American Journal of Obstetrics, vol. iii., 1871.

[3] Nouveau Dict. de Med. et de Chir. Pratiques, vol. xxviii., article Placenta.

[4] Anat. Path., tome i.

[5] Répertoire Gén. d'Anatomie, tome iii., p. 71.

[6] Études Anatomiques sur l'Œuf dans l'Espèce Humaine, p. 123.

POULTICES were formerly one of the most common, as well as most popular, applications for all local inflammations, whether or not complicated with open wounds. Being readily obtained, quickly and easily prepared, inexpensive, and grateful in their effects, they have from time immemorial entered largely into the treatment of very many of the inflammatory affections of the body. Although supplanted in many instances in later years by antiseptics, more particularly in open wounds, yet they are still a favorite application, and justly so, with many practitioners.

Unless otherwise specified in this article, the term poultice will mean one applied hot, *i.e.*, at a temperature of about ninety-two degrees. Poultices act as a local stimulant. By their effect upon the nerves of the skin and of the vaso-motor system, the circulation is increased, congestion is relieved, tension is diminished, the temperature is lowered, absorption is hastened, and resolution, or suppuration, according to the degree of the inflammation, is promoted. It is more than doubtful if the application of a hot poultice determines the formation of pus. That process depends more upon the type of the inflammation and the susceptibility of the individual, than upon any local application which may have been made. Properly prepared and applied, and frequently renewed, a poultice is to most people a most grateful and comfortable remedy. Occasionally it produces irritation of the skin, showing itself in the form of small pustules or acne, and more rarely it increases rather than diminishes the pain and discomfort.

It may be laid down as a general rule that poultices are indicated in any acute localized inflammation attended by the usual symptoms of heat, throbbing pain, congestion, and swelling. Hence they are called for in cases of circumscribed cellulitis, as abscesses, boils, and carbuncles, inflamed lymphatic vessels and glands, phlebitis, diffused cellulitis, and phlegmonous erysipelas. Acute synovitis and acute rheumatic inflammations of the joints are often benefited by this mode of treatment. A jacket poultice in pneumonia is a favorite application with many practitioners, and for a day or for a few days it is often very grateful to the patient. But, as in acute peritonitis, it soon becomes irksome from its weight and disagreeable clamminess. In the early stages of local peritonitis and in pelvic cellulitis, a poultice is one of the most satisfactory applications. But in this, as in most other affections, the feelings of the patient are to be consulted. The effect of a blister is increased and prolonged by the immediate and continued application of a poultice. Chronic synovitis of the knee or other large joints is well treated by the repeated application of small blisters, one or two inches in diameter, and poultices. This treatment, of course, does not preclude fixation, pressure, and aspiration.

Poultices with an occasional blister form a good method of treatment in buboes, and inflamed lymphatics in other localities. They promote resolution or suppuration, as the case may be, and under many circumstances they may be continued even after suppuration has taken place. The writer is confident, however, that the best treatment for suppurating glands is free incision and thorough curetting, followed by careful antisepsis. This opinion is based upon a pretty large experience in a metropolitan hospital, too often a constant abiding-place for this class of patients. These inflamed, broken down glands act as a foreign body, and the process of removal by suppuration and ulceration is a long and tedious one.

Poultices are desirable in the removal of crusts and scabs in certain forms of skin disease, and neglected sores and ulcers. They also serve a good purpose in many instances as a placebo, by preventing the application of all sorts of harmful materials, and that constant meddling and fussing which is so irresistible for some people, until the character of the affection is sufficiently developed to indicate the proper method of treatment. A poultice seldom does harm, even if it does no good, a statement which cannot be made of several applications in common use. Occasionally the tissues become soft, sodden, and flabby, from a too long continuance of poultices. Under these circumstances, repair is more rapid under other dressings. Poultices have been applied to cases of strangulated hernia, under the impression that an abscess was forming, and thus valuable time has been lost. But this was the fault of the diagnostician, and not of the application. Objections have also been made that poultices are not cleanly, and that they become matted. That depends upon the way in which they are made, the material used, and the care taken in their application and renewal. Properly managed, these objections are of little account.

Poultices are made of flaxseed (linseed) meal, slippery elm bark, bread and milk, crackers, hops, poppies, arrow-root, starch, charcoal, yeast, bran, ice, etc., to say nothing of the multitude of domestic articles which enter into their composition, such as apples, carrots, potatoes, turnips, cranberries, tomatoes, spices, etc. Whatever may be the material of which a poultice is made, it should be soft, smooth, moist, free from lumps and other irritating substances. It should be applied as hot as can be borne comfortably, should be well covered and secured in place, and should be changed as often as it becomes cool, stiff, or otherwise uncomfortable. It may be necessary to renew them every hour in some cases; in others they may be left on for from six to twelve hours, according to circumstances.

Poultices may be variously medicated, as with laudanum, digitalis leaves in suppression of urine, carbolic acid, chlorinated soda, permanganate of potash, etc.

For ordinary purposes flaxseed meal makes as good a poultice as anything. It should be freshly ground, as it then contains a considerable amount of oily and glutinous materials, which are very desirable. It is to be stirred into boiling water to the consistence of a thin batter, and is to be thoroughly mixed. It should be smooth and pasty, free from lumps and sticks. It may be spread about one-half or three-fourths of an inch thick upon any kind of moderately firm cloth, lying upon a hot plate or other warm surface. It is then covered with cheese-cloth, muslin, or other thin material, to prevent the meal from drying and adhering to the skin. The edges having been turned in, or, what is better, basted together with a needle and thread, the poultice is to be applied gently and slowly to the part, to accustom it to as great a degree of heat as is desirable without pain or shock. The poultice should be several inches larger than the inflamed area, and is to be covered with oil-silk or paper, rubber, or other impervious material to confine the heat and moisture. Over all may be placed a layer of cotton wadding or batting (the former is more convenient), and the whole should be secured firmly in place by a roller or many-tailed bandage, or by a swathe. It is to be renewed every two to four hours, as a rule. If allowed to remain too long it becomes stiff. Dr. Gross considered the slippery elm poultice as the best that could be made; it is particularly useful in burns.

A most admirable poultice is made of starch, the

"Watertown" starch being the best. Mixed first with cold water, and then added to boiling water and cooked for a few moments, it forms a smooth, cleanly mass, which can be applied hot or cold. The coolness can be readily augmented by allowing hot or cold water to run over it just before it is applied. This poultice is peculiarly adapted to acute, indurated swellings in the cellular tissue, as in the legs, and about inflamed glands and veins. Some forms of eczema and eczematous ulcers are greatly benefited by the application. Arrow-root also makes a good poultice, and it is similar in its properties, in its effects, and in its preparation, to the starch poultice. I have found the latter very useful in preventing bed-sores. One patient with caries of the spine has lain upon a starch poultice for over a year with great comfort.

Charcoal, mixed with an equal quantity of flaxseed meal, is a desirable dressing for foul and gangrenous ulcers, the principal objection to it being that it discolors and thus obscures the parts somewhat. A much better application for this class of affections is the yeast poultice, made of yeast and water, with enough flour to make a thin batter. It is allowed to rise by being placed in a warm locality, and it should be applied in a loose bag, as the process of fermentation goes on for some time, and room is required for the expansion. It should be renewed every eight to twelve hours. For gangrenous affections or bad-smelling sores I know of no better application than the yeast poultice made according to the rules laid down in the U. S. Dispensatory.

One part of "fine-cut" tobacco, added to ten parts of flaxseed meal, is thought highly of by some as an application in acute orchitis. Occasionally it produces symptoms of collapse, and hence care is requisite in its use.

In the absence of ice-bags or cold-water coils, an ice poultice is sometimes a desirable application. It is made by spreading a layer of cracked ice between two layers of bran, and confining the whole in a bag. Care is to be taken to prevent the water from drenching the patient, and the same caution is to be exercised about too great a degree of cold coming in contact with the skin, as in using ice in other ways.

While the poultice is still a valuable application in many cases, yet its use has been very much limited in the treatment of open wounds by the introduction of antiseptics, especially in hospitals. To one accustomed to both methods of treatment, the difference in the results is very striking indeed. The amount of suppuration seen in cases of cellulitis, etc., treated by poultices, was often prodigious. Convalescence was prolonged, and hence pain and suffering were increased, the strength of the patient was more exhausted, the liability to septic and other complications was greater, and much more labor was requisite in taking care of the wounds. The advantages of antiseptics in the treatment of most open wounds calls for no argument in these days. Their value, like that of anæsthetics, has been determined by the crucial test of experience. Time and further experience only confirm the favorable opinion already so universally prevalent the world over. *George W. Gay.*

RACE AND NATIONALITY, INFLUENCE OF, UPON DISEASE. Under this designation it will be appropriate to enumerate and discuss such peculiarities or characteristics associated with the phenomena of infectious and contagious diseases, as are perceived to be dependent upon, or attributable to, differences of race and nationality. It is not difficult to conceive that the various communities of mankind, situated as they are in such dissimilar circumstances of climate, soil, geographical position, and social condition, should manifest contrasts in their morbid proclivities as well as in their physiological tendencies. Man, complying with the general law of adaptation, which pervades and permeates the whole series of living organisms, conforms to the rigid conditions of his existence. Corresponding with fluctuations in the environment there are always fluctuations of adaptation in the internal functions, else the creature perishes or degenerates. While it is essentially true that disease-producing causes or conditions are pretty general in their distribution among every race and people, and each is more or less susceptible to them, so that few or none have complete immunity from any, still observation reveals that these propensities are indicated in very varying and very unequal degrees. Boudin in this connection has remarked: "Man is not born, does not live, does not suffer, does not die the same at all points of the earth. Birth, life, disease, and death all change with the climate and soil; all are modified by race and nationality."

In essaying to estimate the several influences that contribute to the establishment of the disparities that will appear upon a study of the different diseases among different races, it must not be presumed that the determining factors are the same as the normal distinctions usually employed by the ethnologists in discriminating between races. Conclusions based upon such characteristics as color of the skin, quality of the hair, appearance of the tongue, and size, shape, and proportional dimensions of the skull and face, which in themselves could have no possible practical bearing upon morbid conditions, will, therefore, not be considered in this article. An endeavor is now being made by those who hold certain views bearing on this question to demonstrate that variation in susceptibility to infectious disease depends largely upon qualities—vitalities—that pertain to cell life. It is supposed that the difference lies in the contending activities of the pathogenic germ on the one hand, and the vital reaction of the cells of the organism on the other. Changes in the structure and function of each race or nation bring about corresponding differences in their susceptibility to and immunity from disease. As to exactly what this consists of, and as to how these peculiarities originate, we know that a race indigenous to a certain country acquires through many generations characteristics, the formation of which can be traced to circumstances of environment—to those particularly of telluric influence and climate. Again, we know how habits of life definitely determine the susceptibility and non-susceptibility to certain diseases, and that change of environment always induces changes in the physique, mental traits, and morals of any man, group, or even nation of men. These external conditions of life are always intimately associated with the occurrence of disease, statistics showing that any people are exempt from the influence of disease in proportion to their ability to cope with the evil effects of improper hygienic and climatic conditions.

Among these factors of environment that have an unmistakable influence upon the advent and type of disease none is more remarked than that of climate. Considering this in the light of the definition given in Vol. II., p. 185, of this work, that it is "habitual weather," its importance can be readily seen in this connection. Of course, climatic relations of themselves are totally incapable of generating in the system specific disease, yet that they do foster the special causes in certain countries and create constitutional peculiarities and tendencies through molecular modifications in the tissues, which gradually become permanent and capable of transmission through heredity, is a well-established conclusion of a large majority of observers in all tropical countries. Reference to the latitudinal position of the various races of the earth will demonstrate that each one has its own special limits of health defined by rigorous laws of climate. The Icelander who emigrates to Copenhagen is liable to perish from consumption, the tropics of India are wholly inimical to Europeans, and the Dutch have been totally unable to populate Sumatra and Java. The white race is the only one that has been able to colonize at all, and even this seems possible only to a limited extent. It has been found that unless the organism can readily adapt itself to the new external medium, by a readjustment of its internal medium, it deteriorates or dies. In this we see the whole rationale of acclimatization. The white races enjoy the most perfect health and the highest type of physical and intellectual development in the temperate zones, above 40° in the Western and above 45° in the Eastern Hemisphere.

Whenever they migrate many degrees below these lines a series of profound physiological changes set in, which continue in proportion to the length of residence. On the other hand, if we look at the intertropical races approaching the latitude of the white race, we see a host of deleterious influences begin, that gradually grow worse, in proportion to the distance from the equator. As the varied regions have their natural order of fauna and flora, so they have their appropriate races of man; neither can transgress its fixed limits without endangering its existence or incurring deterioration. Man, like the animals and plants, bears the stamp of geographical areas, and while he is able through his intelligence to overcome many of the usual obstacles of climate, yet these digressions are sooner or later found to react upon him, frequently leading to disaster or even death. In some countries everything tends to hinder. Volney says, "that neither the Mamelukes, who were a Caucasian race, nor the Turks, who are Mongolians, unless they married native women, which the Mamelukes never did, could continue their race in Egypt, all their offspring perishing in the first or second generation." Dr. Kenneth McKinnon says of the children in Bengal, that "even where there is no tangible disease, nutrition and oxygenation do not appear to go on favorably; the skin is pale, the muscles wanting in substance and tone; the joyous spirit of children is absent, the body is inert, the mind listless." Children born of English parents in India sicken and die when they pass the age of about six years (Peschel).

This is so well authenticated that the late Mr. Twining states that after much search and careful inquiry, he was unable to find anywhere a sample of the third generation from unmixed stock of Europeans.

No Asiatic race has ever shown that it possessed the power of resistance or the power of progress. The Hindoos were of Caucasian origin, but having been exposed during countless generations to the same succession of depressing influences of climate, a temperament has been developed which differs widely from that of Europeans. This is seen in their want of energy, their incapacity to withstand disease, and their tendencies to early exhaustion, possessing, as they do, neither muscular nor nervous power. In approaching the equator from each side, it has been found that the mortality is increased as we come nearer, and consequently the average duration of life is shortened, observation going to show that the proportional number of individuals who attain a given age always differs in different climates, and the warmer the climate, other things being equal, the shorter the duration of life. An early puberty is always associated with an early decline. In the limits of Europe we find this illustrated, the longevity varying from twenty-eight in the Roman states to forty-six in England. In an estimate made a few years since by Dr. C. F. Campbell[1] upon the adult male members of the order of Odd-Fellows of the United States, he found that the death-rate in the Southern or tropical States was just twice as great as that in the temperate ones of the North, the figures being 30 for the former and 15 for the latter annually per 1,000.

With regard to morbidity, he found that the average sickness in weeks for each hundred was .266 for the Northern States, and .946 for the Southern. Dr. Eklund, of Stockholm, in an investigation of the mortality rates among children under one year of age, in the various nations of the earth, found the lowest among those in England, Belgium, Denmark, Sweden, and Switzerland, where it fluctuates between 14.3 and 26.2 per 100 annually, and the highest in Austria, Russia, and Germany, where it varies between 31 and 48 per 100, the average being, for all Europe, twenty-five per cent. of all deaths. These illustrations are capable of wide elaboration, and they indicate the potent influence of climate and race in *predisposing* the system toward the onset of disease.

Passing to the consideration of another factor that also exercises a very marked influence in determining the character of disease, we do so under the heading of *class* or *social condition*. There can now be but little, if any, question but that this is a very important element in the inception and sequelæ of disease. Among many of the members of the darker races, who exist under the most imperfect hygienic and sanitary surroundings, this influence is widely felt. It has been found that in London the death-rate among the rich is from 12.5 to 25 per 1,000, and for the poor it is from 25 to 35.5 per 1,000. The well-to-do in England have an average life of fifty-five years, while that of the artisan class of Lambeth is only twenty-nine and a half years.

The effects of class upon infectious and contagious diseases has been ably worked out by Körosi, a statistician of Buda-Pesth, and he finds it as follows: Excluding deaths in infancy, he found that the upper class had a longevity of fifty-two years, the middle class of forty-five years, and the poorer class forty-one and a half years. In the matter of susceptibility to disease, he found that cholera, small-pox, measles, and typhoid fever were more prevalent among the poor; and diphtheria, croup, pertussis, and scarlet fever in the well-to-do. Zymotic diseases, as a whole, were sixty per cent. more frequent among those living in basements than in higher domiciles. But the increased mortality in underground tenements applied only to certain diseases, especially measles and pertussis, while diphtheria and scarlet fever were ten per cent. less fatal than in people living above ground. In regard to other statistics of this character it has been shown that, in Dublin, in the first class of society, including professors and independent people, the mortality was 22.5 per 1,000. In the second, or middle class, it was 25.4 per 1,000. For the third class, composed of shopkeepers, artisans, etc., it was 26.1 per 1,000; while for the fourth class, occupants of workhouses, jails, and those in general service, it was 37.5 per 1,000.

Along with these elements that act as predisposing conditions to disease, we have others, doubtless equally or more influential. There seem to be certain qualities of the individual organism that have a very potent influence in warding off or inviting pathogenic factors. So far investigation has not furnished much that is tangible and certain in this field, yet the future appears to be filled with great possibilities for science. In a series of articles published in *The Lancet*, in 1888, upon the pathology of infectious and infective diseases, the well-known pathologist, Joseph Coates, of London, states his conclusions as follows: "We have seen that, in the case of a large number of diseases of this class, inheritance, whether we take it more broadly in the race or more particularly in the family, has an undoubted and frequently a very great influence on the susceptibility to infection. This varying degree of susceptibility exists in the case of diseases which are demonstrably due to the action of micro-organisms, and we are driven to the conclusion that a micro-organism which is pathogenic in the individuals of one race to a high degree, is non-pathogenic, or nearly so, in the individuals of another race. Recurring to our remarks on the general principles of inheritance, it seems necessary to refer this difference in susceptibility to fine differences in the structure and activity of the tissues. We have seen that the differences in the races depend on variations in the details of their tissues, such as might singly seem to be of comparatively little moment. The differences in individuals of the same race are still more minute, and depend on still finer variations in the details of the tissues. Coming to undoubted cases of inheritance of morbid conditions, we saw by illustration that it was variations in the details of structure and function which are the subject of inheritance. In ichthyosis it is the structure and mode of growth of the epidermic cells; in hæmophilia it is the structure, presumably, of the blood-vessels; in Daltonism, the finer details of the structure and function of the retina.

"In all these cases it is the structure and activity of the finer elements of the tissues concerned that are at fault. When we find that the varying susceptibility to infectious and infective diseases is also related to inheritance, then we must, I think, relate it to the same kind of variations as those which we have found to be the subject of inheritance, both of normal and abnormal structure. It is, again, the structure and vital activities of the elements of the tissues with which we have to do. If, as we have seen, the negro race differs very markedly in its susceptibility to infectious diseases from the European races, then we are led to believe that this depends on the differences in the structure and activity of the tissues, such as determine the characters of race. It is the living activities of the tissues with which we have to deal, and it is peculiarities in these, determined by inheritance, which, I believe, constitute the differences."

The foregoing illustrates very lucidly the influence of heredity, and shows how diatheses may contribute certain conditions favoring the reception of disease germs. However, there are good reasons for supposing that there are many other circumstances in this same connection which are equally potent in their influence. Experience demonstrates that a large majority of the individuals of every race and nation are born, it would seem, with more or less susceptibility to acquire certain of the diseases belonging to the zymotic class—a class presumably due to morbid animal poisons. There is evidently in the organism some inherent principle or ingredient, the character of which we now understand very imperfectly, though clearly it is in no way essential to life or health, by which the human species, and in some instances animals also, are rendered liable to these diseases. That this liability is in some way closely allied to the constituents of the blood, seems highly probable. The germ theory of the cause of this class of diseases, rests upon the principle that bacteria can only become noxious after entering the circulation, and are hurtful in exact proportion to their capacity to multiply there. Ziegler says of the factors which determine bacteria in the blood, "there must be a certain predisposition to favor their development." This is but another name for susceptibility, of which we have two kinds, the congenital and the acquired. As to the congenital form we have seen that it consists in peculiarities of tissues, such as it is possible for the factors of environment to originate, though they are transmitted from parent to offspring under the influence of heredity. In the acquired form of susceptibility, which may be absent at one period of life and present at another, it seems probable that the system is changed by similar circumstances from its original character, and rendered liable to the assaults of the pathogenic causes, though it is possible for other causes to operate in the same manner, as will be seen from the following:

In an article in the *Centralb. f. Med. Wiss.*, 5, 1882, Rossbach has shown that the injection of papayotin into the vessels is followed by a rapid development of micrococci in the blood of the heart, so that in two hours it was found swarming with them. From this it appears that the composition of the blood is capable of being so altered by the addition of a chemical substance as to cause it to develop germs. In other words, that the addition of a vegetable substance has brought about a special predisposition or susceptibility. The evidence appears to show that the presence of germs in the system, aside from the influences that go to favor their entrance, is properly ascribed to certain ingredients in the blood that occupy the relation of pabulum to the bacteria, and in the absence of which their existence and propagation is impossible.

With regard to the immunities that are found to favor certain races with respect to certain diseases, several theories have been advanced in explanation. The first of these is known as the exhaustion theory. We know as a matter of common experience that an immunity is secured, as a rule, by single attacks of such parasitic diseases as small-pox, measles, typhoid fever, and the like, and that an individual is thereby rendered apparently insusceptible to future attacks. Reasoning from analogy, it would appear that the second attack is guarded against by the removal from the system, through the first attack, of some ingredient or condition necessary for the sustenance of the pathogenic microbe that stands in the relation of cause. This, then, in brief, is the basis of the theory of exhaustion. The second of these theories, known as the antidote theory, presumes that the organisms in multiplying and growing in the system generate chemical substances, ptomaines or other poisonous matters, that act as antidotes to future infection. The artificial cultivation of micro-organisms is now carried on to such an extent as to enable everyone to appreciate how small a change in the composition of "culture fluids" will often frustrate the growth and life of the contained germs, since the addition of an infinitesimal amount of any substance inimical to their welfare is attended with the most striking and frequently disastrous results. For example, one part in sixteen hundred thousand of nitrate of silver added to the culture fluid of the aspergillus niger, stops the growth of the plant and reduces its productive capacity three-fourths. Now, supposing this to be a human parasite—a living contagium—capable of self-multiplication in the blood and tissues, and of so altering them as to induce disease or death, then the introduction into the system of a minute portion of this salt of silver would insure, if not the total effacement, at least the neutralization of its powers for harm. This relation of the organism to its medium is one of the most fundamental of biological data, and applies to every form of life and every condition of existence. The third of these theories holds that the tissues concerned in the conflict with the morbid causes possess an educated capacity, through the first attack, to withstand future attacks by the same infection. This is the tolerance theory. It assumes that each generation of cells has transmitted to it by parent cells certain peculiar qualities which enable it to resist future encroachments. This, of all the explanations furnished, seems most worthy of acceptance, interpreting as it does both the immunity following a single attack of these diseases, and that which is known to exist in certain people as a congenital peculiarity.

Metschnikoff says the white blood-corpuscles, in disease, are eaten up by the bacteria, but when the individual is in perfect health they are successful in the contest, destroying the microbes as fast as they enter the organism. Hess confirms this in a manner, and says "after inoculation in those species of animals that are immune to the virus, the white blood-corpuscles were loaded with bacteria." Whether the active mediums of resistance be chemical substances, the activities of the cellular tissues, or the white blood-corpuscles, or all of these in combination, the investigations of Maurel show that the blood of the different races presents variations as to the number of corpuscles. In his observations he found that in each cubic millimetre of blood the Hindoos had 5,549 white corpuscles; the Khmers, 5,519; Europeans, 5,000; Chinese, 4,611; Annamites, 4,123, and the Blacks, 3,823. Of course the quality and quantity of food has an important influence upon these components of the blood, but there are also differences in the number of red blood-corpuscles, and while the black races have the lowest number of white blood-corpuscles they lead in the matter of red blood. The differences in the several races were found to be, in each cubic millimetre of blood, as follows: Blacks, 5,412,256; Indo-Europeans (Europeans), 5,000,000; Hindoos, 5,008,222; yellow races: Khmers, 4,474,751; Chinese, 4,584,861; and Annamites, 4,298,781.

How far these discrepancies are to be taken in explanation of the various degrees of susceptibility and immunity that are found to characterize the different races and nations, in the accounts that follow, is still a question requiring solution. Viewing "the blood as the life," and that a capacity to resist any and all diseases of this class is directly proportional to its perfectness in composition, it can readily be seen that the blood may also act the part of a protecting agency, one capable of thwarting the assaults of the pathogenic micro-organisms. The struggle for existence between these minute organisms and cells is doubtless just as real and important to life as those grosser changes that can be seen and appreciated. A detailed description will now be given of the various diseases that observation has found to be characterized by differences of susceptibility and immunity, in connection with their history as manifested among the different races and nations. It is but just that the author should here express his indebtedness to "Hirsch's Handbook of Geographical and Historical Pathology" for much of the data contained in the accounts of diseases that follow.

PHTHISIS.—No race or nationality enjoys complete immunity from phthisis, but with respect to frequency there are marked contrasts as to place and people. Taking the mean death-rate for the whole world at 22 per 1,000 of population, and the average of phthisis to be 3 for 1,000, we find that the deaths from consumption to be nearly one-seventh of the whole mortality. The following table, taken from Hirsch, shows the variations, with regard to its frequency in Europe and other portions of the earth :

Locality.	Period.	Deaths per 1,000 population.
Norway	1854 to 1867	2.21
"	1871 to 1875	2.53
Sweden	1861 to 1876	3.5
Denmark	1876 to 1883	(For small towns) 2.12
Germany	1877 to 1880	3.6
England	1848 to 1855	3.0
"	1859 to 1869	2.5
Wales	1848 to 1855	3.3
"	1859 to 1869	3.1
Holland	1869 to 1874	2.46
South Holland	1869 to 1874	2.28
Switzerland	1865 to 1869	1.86
East Indies	1850 to 1860	3.0
Algiers	1852 to 1859	2.9
Brazil. Pernambuco		5.2
Rio de Janeiro	1855 to 1858	5.0
Monte Video	1871 to 1875	4.0
Melbourne	1865 to 1870	2.22
Venice	1862 to 1885	4.04
Milan	1861 to 1870	3.69
Turin	1855 to 1867	2.39
Rome	1874 to 1878	3.45
Berne	1865 to 1869	3.9
London	1848 to 1855	3.7
"	1859 to 1869	3 2
Christiania	1866 to 1875	3.45
Stockholm	1861 to 1876	4.1
Copenhagen	1876 to 1883	3.0
Boston	1811 to 1840	3.8
"	1846 to 1848	3.8
New York	1805 to 1837	5.3
"	1870	4.1
Philadelphia	1807 to 1840	5.6
"	1870	3.1
Baltimore	1819 to 1826	4.1
"	1838 to 1854	4 0
"	1870	3.7
Charleston, S. C	1870	3.9
Mobile, Ala	1870	4.15
Wilmington, N. C	1880	1.9
Hamburg	1871 to 1883	3.4
Würzburg	1871 to 1879	5.4
Vienna	1865 to 1874	7.7

These figures are as reliable as it is possible to obtain, and they show very marked differences in the death-rates from consumption as to time, place, and people. Among the most noteworthy facts associated with the distribution of phthisis is, that it is as common in sunny Italy as in foggy England, and that it is absent from the islands of the northern latitudes, such as Iceland, Faröe, Shetland, and the Hebrides, where the disease is practically unknown. It seems to be more common in Sweden than in Norway. In the island and mainland of Denmark it stands at about the average mean of frequency, and the same is true of Russia in Europe. In England the heaviest mortality is in London.

In Ireland consumption is the chief source of mortality ; indeed, wherever the Irish race is found, this liability and destructiveness of tuberculosis crops out. As to the lightness of the death-rate in Switzerland generally, where the average is the lowest, being only 1.86 per 1,000, there are marked contrasts in different localities. In Frieburg it is as low as 0.81, while in Baselstadt it is as high as 3.57 per 1,000.

In France the centres of mortality are cities, the same being true of Spain. Italy has a general average of 2.45, which varies in places from 0.89 at Basilicata to 3.34 in Lombardy. In the eastern countries of Asia, such as Persia, Syria, and Armenia, the disease has but little influence on the death-rate ; these parts being almost totally free from it. The nomadic life of the people in these countries has doubtless much to do in keeping off this disease, since when they exchange their tents for houses it is seen to occur. M. Robinson, of Constantinople, sent a communication to the "Congress for the Study of Tuberculosis," held in Paris, July, 1888, in which he states that, notwithstanding the fact that the inhabitants lived much in the open air, and under the best hygienic conditions, tuberculosis was now very prevalent, and ten per cent. of all his patients were suffering from this disease. It is said that the disease is rarer in India than in corresponding zones of the Western Hemisphere, though there it is upon a gradual increase. Boudin maintains that there exists an antagonism between malaria and phthisis. This is corroborated by M. de Brun, of Syria, and Piot, of Cairo. The type of the disease as it occurs in some places, such as Ceylon, China, and Japan, seems to be particularly malignant. Verrier says it is very common in all the yellow races. Within the last fifty years there has been a considerable increase in phthisis in the interior of Brazil and the other states of South America. In Victoria, Australia, in 1866, this disease caused six per cent. of all deaths, while in Melbourne it rose between 1865 and 1869 from 2.22 to 2.52. The mortality at present among the inhabitants of South Australia is 1.008 per 1,000.

Among negroes and Indians this is the leading cause of death, but whether these preponderances are due more to race peculiarities or to unpropitious circumstances of life, there seems to be some doubt. That change of climate does have a considerable effect is well known. Of the British soldiers sent to the Bahamas, the deaths were—for each 1,000 of whites 2, and of negroes 7. Among those sent to Gibraltar, the proportions were 6.1 for whites, and 33.5 for negroes, in each 1,000 soldiers. In 1803 and 1810 the British Government imported three or four thousand negroes into Ceylon ; in 1820 there remained only four hundred and forty all told.

Says Bartolacci, in his book upon Ceylon : "It is a remarkable fact that of nine thousand negroes, from the East Coast of Africa, who have been employed as soldiers by the Dutch Government, scarcely a trace of them remains." Here we have a very pronounced confirmation of the fact that migration to a colder climate by the negro is always followed by a rise in the susceptibility to phthisis. Pruner calls attention to the fact that at Khartoum, latitude 17° N., with a temperature lower than that of the mountains around, consumption ensues among negro captives, as well as among the Arabs of the desert, whenever they lay aside their nomadic habits and live in houses, even when it is in a warmer climate. This certainly has an important bearing upon the question of the increase of phthisis among the negro population since the Civil War. The change in their mode of life has brought about an effeminacy of constitution which has greatly added to their liability to enthetic diseases.

In the United States the censuses of 1850, 1860, and 1870 show that for this period the whole country had a mortality ranging between 2.51 and 2.54 per 1,000 population, though in the Western States it was as low as 1.11 and 1.34. A comparison of the cities of the North and South shows that the average in the North is 2.82, while in the South it is 4.25 per 1,000 population. We must look for the causes of this disparity in the preponderance of the colored element in the Southern cities. This affords an interesting proof of the observation that phthisis is largely diffused through the urban population, and that it is at these centres that we find the highest death rate. In the convict prisons of this country, from 1829 to 1845, the average mortality among whites dying from phthisis was 11.16 per 1,000, but in the penitentiary of Pennsylvania it was for blacks 40.74, and for those in Maryland prisons 28.49. The negro population of New York, under the same restrictions, had an annual mortality of 11 per 1,000. Corson, of Savannah, in his observations upon "The Future of the Negro in the United States," says that the mortality of the race from phthisis according to his experience is twice that of whites.

PNEUMONIA.—This takes rank with the universal diseases. In the cooler and temperate latitudes of Europe and the United States the deaths are found to average about 1.5 to 1,000 of the population, the proportion sinking as low as 1.1 and rising as high as 2.5. The following table will give an idea of where the contrasts are found:

Place.	Period.	Deaths per 1,000 inhabitants.
[illegible]	[illegible]	1.6
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2.1
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2.2
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]
New York	[illegible]	[illegible]
Philadelphia	[illegible]	[illegible]
	[illegible]	[illegible]

From the foregoing it will be seen that Philadelphia has the lowest record of any city, and Paris the highest. The British Collective Investigation Committee, in 1884, ascertained from 1,059 cases that there were 704 males with 120 deaths, being a mortality of 17 in the 1,000, and 356 females with 71 deaths, being a mortality of 19. This shows that while the disease is less frequent in women than in men, yet it is more fatal. Dr. Billings says that "the evidence furnished by the census does not favor the theory that this is a disease dependent upon or favored by cold." In the northern sections of Europe it is moderate in extent, and not more severe than in the warmer climates; while the southern countries of Greece, Turkey, and Italy, have it very often and severely. The death-rate from pneumonia for Rome is 4.1, Bologne, 2.7, and Genoa, 2.9. Venice is known to have a peculiarly fatal form of the disease.

While immigrants from the northern latitudes to subtropical or equatorial regions enjoy comparative immunity from inflammation of the lungs, the natives of the tropics, and most of all the negro, are subject to the malady in quite a peculiar degree; this is not merely so when they go to colder climes, but also in their natural habitat. In North America, epidemic pneumonia among negroes is prone to take on the dreaded typhoid form, in which case it is signally fatal. The pneumonia of the desert, which has been often epidemic in the Soudan, Zanzibar, and in the West Coast of Africa, generally destroys all those attacked. Lower Egypt and Tunis are said to enjoy exemption; but, on the other hand, the negroes of the Upper Nile basin suffer. In the West Indies the negro race is said to furnish by far the largest contingent of sick. The islands most subject to the disease are Cuba, St. Thomas, and St. Domingo; those most exempt are Guadeloupe, Barbadoes and Martinique. From the coast of Cayenne all observers agree in reporting the frequency of pneumonia in negroes, creoles, and natives. The same is true of the South American countries of Brazil, Peru, Chili, and Paraguay.

GOITRE AND CRETINISM.—These diseases are very narrow in their bounds and are always apparently associated with definite conditions of locality. On European soil the headquarters are the western and southern slopes of the Alps of Italy, Switzerland, and France, and the eastern continuation of the chain into Austria, the Pyrenees, the Vosges, and the Jura.

Sormani has shown that, in Italy, out of 2,000,000 men liable to military duty, 20.9 per 1,000 were disqualified owing to goitre. In France it has been shown that the proportion of goitrous persons is 10.4 per 1,000 and of cretins 5.0 per 1,000 of the whole population. Spain is none the less liable, and here, too, we find the disease widely prevalent. For Switzerland the proportion to the whole population was in 1868 1.7 per 1,000, one-seventh of these being confined to the canton of Valais.

The distribution of goitre in Austria is found to vary in the different sections, being for Cilli 2 per 1,000 and Judenburg 21.3 per 1,000. In Germany it is found in the Black Forest, along the Danube, and in Halle, where it is 1.54 to each 1,000 of population.

The amount of goitre found in England is proportionally very large, especially in the southern and midland counties. Scotland is much less subject to it, and in Ireland it may be considered as absolutely rare, though Law (*British Medical Journal*, 1882) has reported its presence in a few localities. Cretinism is very rare in Great Britain, and it has been known to occur only in few places and at considerable intervals of time.

The higher countries of Scandinavia are almost entirely free from both diseases. Russia in Europe has little or none, though in Siberia in some villages the number of those affected reaches as high as twenty-five per cent.

It occurs in Asia, especially on the slopes of the Himalayas, where Fayrer estimates the disease to affect as high as ten per cent. of the population in certain sections. Very little of this disease is known in Africa, though there is sufficient evidence of its presence in Egypt, Algiers, Morocco, and along the coasts.

A noticeable fact associated with the distribution of these diseases is that while goitre is widely spread in the Western Hemisphere, cretinism occurs much more rarely than it does in the Eastern, or than it does on the continent of Europe in particular.

Greenhow says for India, and Barton for America, that they have never seen a case of goitre among the white natives, whereas according to the experience of Fayrer and Wilson, the disease is equally common among all races. For Nicaragua, the accounts of Bernhard and Guzman agree in stating that goitre is most frequent among the Indians and rare among those of mixed blood. Barton says that it is epidemic among certain of the American Indians. Praslow says that it occurs among the Indians of California ("Der Staat Californien," 1857). Smith found goitre very frequently among the negroes and whites of Peru, but rarely among the mestizos and Indians. Tschudi says for Brazil, "it is equally common among negroes, mulattoes, and whites."

How far these reports can be harmonized, and the conflicting statements made to agree, does not appear. Whether these differences, such as they are, in the amount of the disease in mixed populations are attributable to race peculiarities appears somewhat doubtful. At all events, the above facts as well as the fact that the disease is endemic among Indians (Barton), among the Malays of Sumatra, Java, and Ceylon, among the Mongols in Ladak and China, and among the natives of Algiers and Morocco, make it very doubtful whether any race or nationality enjoys an immunity from it. In New Granada it appears from the statements of Humboldt and Roulin that the disease is rather uncommon among the Indians, though the latter adds, "it is very common among the negroes and whites." It occurs in the countries of South and Central America, Mexico, and as far south as Chili. In some sections of Nicaragua and Costa Rica (Bernard and Swalle) whole towns are afflicted with it, though cretinism does not seem to be associated.

SYPHILIS.—This is a disease which is thought to be pretty generally distributed over the entire globe, yet when we come to examine the statistics regarding its visitations we shall doubtless be surprised at the contrasts presented. There are certain sections, among which may be mentioned Iceland, Greenland, Newfoundland, South Africa, Madagascar, and the adjoining islands, which seem to be particularly free from the ravages of this disease. Syphilis has been imported twice into Iceland, once in 1756 and again in 1824, which infected the inhabitants to the extent of twenty-two cases. Finsen says of his own personal experience there, in a practice of nine years, that he saw only five cases and these in strangers. Of Newfoundland, where it came with the first settlers of the island, Gras says, "I have not found a single trace of it having been developed, and I have never seen an infant that would justify its being transmitted by heredity." Lange says of Greenland: "It is a remarkable fact that there is absolutely no syphilis here; about the fact there is no doubt, and the strangeness of it will be less when we remember that the same is true of Iceland. The circumstance is explicable simply and solely on the ground that Greenlanders and Icelanders have immunity from syphilis, for there is no lack of opportunities for infection, since vessels frequently visit here with syphilis on board, and prostitution is far from uncommon."

In this connection Fritsch has said: "Syphilis is rare (in Central Africa) and it occurs in Bechuana Land only in scattered cases, mostly imported from Cape Colony, though there are materials with which to controvert the assertion that the disease does not hold with pure Ethiopian blood." Borius and Darwin say that the negroes in Madagascar are exempt, while the Hovas, of the Malay race, are frequently and seriously affected with it. It has been found that Europeans infected at Chinese ports are much more severely affected with it than the natives. This seems also to give rise to the notion that syphilis contracted from the darker races is serious in the whites, something which my professional experience corroborates. The first cases of this disease that reach a country are generally the worst. Aborigines, as a rule, suffer more than immigrants. In contrast to the assertions made by Livingstone, it has been found that the negroes of both coasts of Africa have it badly and suffer equally with any race. From a study of two hundred and thirty-one cases occurring in negroes, Dr. Henry R. Carter ("Report of Surgeon-General Marine Hospital Service," 1883) was enabled to make the following deductions: "To conclude, it may be stated that syphilis pursues a mild course in the negro race, milder than in the white. It is marked by but few cutaneous lesions; . . . nodes and periostitis rare, caries and deep ulcerations rare in early syphilis."

How far the factor of race is accountable for this exemption, is not plain. The Icelanders belong to the Scandinavian stock, which pays a heavy tribute in Norway, Sweden, and Denmark. The Greenlanders are of the same blood as the Eskimos inhabiting the west coast of North America, and the latter have had terrible visitations from it in the past.

Livingston says, in his "Travels:" "A certain loathsome disease which decimates the North American Indians and threatens extirpation to the South Sea Islanders, dies out in the interior of Africa without the aid of medicine. And the Bangwakatse, who brought it from the West Coast, lost it when they came into their own land southwest of Kolobeng. It seems incapable of permanence in any form in persons of pure African blood anywhere in the interior of the country. In persons of mixed blood it is otherwise, and the virulence of the secondary symptoms seems to be, in all the cases that came to my care, in exact proportion to the greater or less amount of European blood in the patient. Among the Coronnas and Griquos of mixed blood, it produced the same ravages as in Europeans; among the half-blood Portuguese it was equally frightful in its inroads on the system, but in the pure negro of the central parts it is quite incapable of permanence."

The last census shows that forty-three per cent. of those reported as dying from venereal disease were children under five years of age. In those parts of the country where distinctions are made between white and colored and Irish and German parentage the proportions are: Colored, 3.0; whites, 1.7; Irish, 1.4; and German, 1.3 per 1,000 deaths from known causes. In England and Wales the deaths from syphilis were, in 1880, 4.1 per 1,000 deaths from all causes. The Pacific coast shows the highest rate of any section, being for San Francisco and Oakland 7.38 per 1,000 deaths. In an article published in the *Philadelphia Medical and Surgical Reporter*, June 9, 1888, the writer called attention to the fact that "syphilis is more common—both the hereditary and the acquired forms—in the Southern negro than in the white race, and is, as a rule, more amenable to treatment than in the white or mixed races" ("Diseases of the Southern Negro"). Corson, of Savannah, says of syphilis: "The most aggravated cases in my practice have been among the colored, the secondary and tertiary symptoms are severe and prolonged, and the inherited form is very fatal," which, by way of contrast, shows that experiences are liable to differ.

Measles.—Susceptibility to the pathogenic factors of this disease is seen, from its general geographical distribution over the entire earth, to be almost uniformly shared by the whole of mankind, of whatever race or nationality. Among the colored races it is seen in its worst forms and leads to disastrous results exceptionally often as compared with the experience of the whites. The reason for this has been thought to lie rather in their unfavored conditions of life than in any pronounced physiological peculiarity inherent in them. This disease seems to be quite independent of all climatic influence, though it does occur mostly during the colder seasons of winter, spring, and autumn. It seems to run an equally mild course in tropical and subtropical regions as in the temperate, though in some particular sections, as in the Himalayas, in Madagascar, and in Honduras, it takes on a particular malignancy of type. Fuchs says in this connection: "There are certain parts of England, France, and Holland where the disease is most malignant, especially in the presence of malaria."

Squire has written in the *Medical Times and Gazette* for 1887 an account of the epidemic in the Fiji Islands which destroyed 20,000, or nearly one-fourth of the entire population. In the epidemic which prevailed in 1865 among the Confederate forces engaged in the Civil War, there occurred 38,000 cases, and 1,900 deaths, a mortality of 52.0 per 1,000, which in some instances reached as high as twenty per cent. in the hospitals.

During the siege of Paris (1871), out of 215 of the Garde Mobile who contracted measles 86, or forty per cent. perished. Masterman says of the epidemic that swept through the National Army of Paraguay, at the beginning of the war with Brazil, that it carried off nearly one-fifth of the entire army in three months. It is known that among uncivilized people the mortality from measles is sometimes truly appalling, since it is always here that the disease assumes its worst type. In an epidemic occurring in 1749 among the Amazons, of Brazil, 30,000 died; in some instances scarcely a vestige of tribes remained. At Astoria, in 1849, among a tribe of Indians, one-half perished from measles; the disease was equally fatal at Hudson Bay, in 1846, and also among the Hottentots in 1852. Fuchs says: "In the north and in the elevated districts, the inflammatory form occurs, while in the south and in the flat places it is more usually the asthenic and putrid forms."

Hirsch considers malignancy due more to mistakes in dieting and treatment than to other influences, and he accounts for the great diversities in epidemics upon these grounds. Corson (New York *Medical Times*, 1887) says: "The eruptive fevers go hard with the colored. I have seen three epidemics of measles, which were very severe and which carried off many (colored) children."

Small-pox.—It is a matter of common experience that the colored races, and especially negroes, are, *ceteris paribus*, in greater danger from small-pox than the whites. Sir Ranal Martin says he has never seen a case in India in a European child, but that there was not a year in which it did not occur among the natives. Hirsch looks upon India and Africa as the native foci for this disease, and certain it is, that the disease is very common among the yellow and black races of the East. "The members of the human family," says Pruner, "that are most susceptible to this poison are negroes. Not only in their native lands, but in other parts of the world as well, they are the first to succumb to the epidemic influence, and the last also."

He says further: "It is no unusual thing to see negroes attacked as soon as they arrive in Egypt (where they certainly change their ways of living as well as climate; and that, too, in those where the disease does not exist among the other inhabitants." Similar statements, equally positive of the liability of negroes to the disease, are made by Daniell for the west coast of Africa, by Rufz for Martinique (according to his observations in the epidemics of 1836-37 and 1848-50), by others for Curaçoa and Cayenne, and by [illegible] for Peru. During the epidemic which spread over Boston (1792) there died 10.8 per cent. of the whites and 24.7 per cent. of negroes.

In the epidemic of Baltimore in 1880 the deaths in 10,000 were 8.1 for whites and 14.5 for blacks. In a city of sixty thousand, several years since, the author had a personal experience with about one hundred cases of small-pox, in which the mortality was between eight and ten per cent. among negroes, and of the few cases among the whites none died. Climate and season appear to have very little influence upon the type of the disease, although the more northern countries of Europe suffer very severely in some epidemics.

Carson says: "In the years 1865-1877 small-pox prevailed in Savannah, and the death-rate among the colored was very high; the disease was invariably severe and left the patient deeply pitted."

SCARLET FEVER.—The area of diffusion of this disease is much less than that of either small-pox or measles. That the continents of Africa and Asia, which are the principal seats of these two diseases, have never been extensively or severely visited by scarlet fever is somewhat remarkable. As a rule this disease occurs less frequently than any of the exanthemata, and in some places ten to twenty years elapse between its visitations. Withering, one of the earliest and best authorities upon scarlet fever, states, upon the experience of his Birmingham practice of 1778, that the disease raged severely in many elevated and dry places, while the dwellers in low, damp, ill-ventilated parts of the town suffered to only a slight degree. Graves, in his "System of Medicine" (1843), says of the epidemic of 1839 in Ireland: "The nature of the disease was not in the least affected by the situation of the dwelling, it being equally bad in Dublin as in the hills." The origin and first habitat of scarlet fever is involved in obscurity, and in its early history it was linked with measles. The influence of place, time, and race are very marked upon the types of this disease. Pruner says that so far as he knows the colored races are exempt from scarlet fever. According to Moulin it occurs very rarely among the negroes of Senegambia. Frick, of Baltimore, has an account in the *American Journal of the Medical Sciences* for 1855, from which it would seem that the negroes and whites of the United States at one time suffered in nearly equal proportions, the ratio being, in the epidemic at Baltimore, in 1850-54, for whites a mortality of 13.8 per 10,000 population, and for blacks 10.8 in the same number of people.

According to the accounts of Brunel, Sigaud, and others, in South America, the disease is often of the same type among the colored races as among the whites. Matthewson (*Edinburgh Medical Journal*, 1849) says that the negroes really suffered more than the whites. Of the North American Indians, in Canada, Stratton says: "In epidemic scarlatina it appeared to me that the Indians were less susceptible of an attack than the whites." This disease has always been rare in the Southern States and the contrast is now greater than ever. The last census reveals that the mortality from this cause is for whites 28.9 and for blacks only 8.9 per 1,000 deaths from all causes. The large cities show a preponderance of deaths. With regard to nationalities the Germans have a death-rate of 30.1 and the Irish 24.0 per 1,000 deaths from all causes. Scarlet fever is more prevalent in the northern part of the United States and in Europe than in other countries. It appeared in England and Scotland in 1601 (Sibbald, "Scotia Illust.," 1684). When and where it first appeared in Asia and Africa cannot now be even approximately stated. It first showed itself in North America in 1735, in South America in 1829, and in Australia and Polynesia in 1847. It occurs commonly in Germany, France, Scandinavia, and Russia, going as far north as Iceland, though Greenland has escaped, and it is seen rarely in Newfoundland. In this country and in England and Wales this disease has shown a very marked decrease in the number of cases during recent years.

DIPHTHERIA.—This has become one of the most common diseases of modern times, both in its wide geographical area and in its general prevalence among races and nations. Since 1856 the disease has become diffused throughout North America and Europe. The statement of Odriozola, that the negro is protected in Peru against diphtheria as he is against yellow fever, is contradicted by Tschudi, who says very emphatically that it is just the children of the negroes in that country that suffer most from malignant sore throat, an assertion that has found support in the published experiences of Goldsmith, of Oakland, Md., and of Smart, of the Bermudas. Unfortunately we have little or no reliable information of this disease among the natives of the interior of Africa in their natural habitat. The only instances of its occurrence among them being in Senegambia, and the west coast, where the cases were sporadic, although in South Africa there was an epidemic in 1866, of which we have few or no details. On the eastern coast the disease has been more or less indigenous since 1857. Pruner found it in Egypt, and it is said to occur also in Algiers and Tunis. With regard to its manifestation in the mixed population of this country the last census reveals the fact that the mortality among the whites (52.63) is more than twice that of the negroes (23.27), the Indian coming between the two with a mortality of 37.36 per 1,000 deaths from all causes.

The inference drawn from these figures would seem to indicate that there is some protecting influence surrounding the colored race, but whether this is due rather to want of disease-producing causes than to insusceptibility on the part of the race is still to be determined. There have been several epidemics in India, the first, a disastrous one, occurring in 1800. Persia was visited by the dread affliction in 1874-78. It is stated that Syria, up to 1868, had not been visited by any serious forms. Asia Minor and Smyrna suffered severely from an epidemic in 1865.

The deductions made from the exemption of the Chinese during the epidemic in Victoria, that the Mongolians are not liable to contract the disease, has not been borne out, since, according to Dudgeon, it is widely diffused through Northern China and has also not spared the Japanese. It is stated that during the epidemic at Pekin in 1866 there died from diphtheria no less than twenty-five thousand Chinese. Southern China, according to the English reports, has so far escaped the disease, though Japan was visited by an epidemic in 1877, and Yokohama suffered severely. The mortality from this disease fluctuates widely during different periods of time, but experiences drawn from the study of statistics would lead us to conclude, upon the whole, that the disease has a decided preference for those of the white race living in the northern latitude, and that the proportion of susceptibility ranks first for the white race, secondly for the yellow, and lastly for the black.

CHOLERA INFANTUM.—With regard to the influence of race upon this disease, it should be mentioned that Frick, of Baltimore, in 1855 (*American Journal of the Medical Sciences*, 1855), regarded the mortality as being twice as great in the white as in the colored race. However true this may have been during his day, the opposite is now nearer the true condition of things. This disease certainly occurs all over the globe and is proportionally worse in those localities where impurities of water and soil exist, together with great heat and a crowded population. We are indebted to Benjamin Rush for the earliest account of cholera infantum in this country. The last government census gives the deaths from this disease as follows: Whites 99.1, colored 71.2, Irish parentage 68.0, and German parentage 90.1, per 1,000, though it must be added that the term employed by the enumerators—

Diarrhœal Diseases—also embraces dysentery, enteritis, cholera infantum, and cholera morbus. The death rates in the large cities of the United States is a little over ten in a thousand more than for the rural parts. The regions showing the greatest prevalence of this disease are the Upper Mississippi Valley, Texas, part of Missouri, Kansas, Georgia, and South Carolina. In Massachusetts and Michigan the deaths from cholera infantum amount to 15 per cent. of the total mortality, and in Boston it is 22.18 per hundred. In New York City, the deaths from 1805 to 1837 were nearly 2 per 1,000 of the whole population. During recent years these figures have increased considerably. In Philadelphia the mortality, in 1872, was reckoned at 2.6 per 1,000 population ("Transactions of the Pennsylvania Medical Association, 1873"), while from 1819 to 1860 it amounted to from one-fourth to one-third of the deaths from all causes. This disease is attended with a frightful mortality in some of our larger cities. In St. Louis (1841 to 1843), and at Memphis, which has been denominated the graveyard of children, it is very high (Grant, *American Journal of the Medical Sciences*, 1853).

We possess little information of this disease in Mexico, Central and South America. At St. Pierre, in Martinique, according to Rufz (*Arch. de Méd.*, Nov., 1869), it is the chief cause of death among children during their first year.

At Barbadoes, Jackson says that "it is by no means as common as might be expected from the tropical situation." For Asiatic countries there are no accessible data, but the inference would be that it is very fatal, owing to the general prevalence of choleraic disorders. Richardson asserts (*Edin. Medical Journal*, 1869) that the mortality from this cause is large in Australia. For Africa the only mention of the disease is at Port Said. Of its occurrence among the colored children of the Northern States little has been written. Corson, of Savannah, in an article in the *New York Medical Times*, 1877, claims that the deaths from this cause among negroes are double those of the whites. My experience leads me to believe that the colored children who suffer from this disease in nearly every instance die, the bad qualities of the lack of diet and attention telling fearfully upon them. In European countries the opinion is unanimous that this is one of the leading, if not the first cause of death in children. There is little difference in the statistics of the cities of the Eastern and Western Hemispheres. In Berlin the death-rate per 1,000 population was (1877 to 1882), 2.6; in Hamburg (1874 to 1884), 1.9; in Stuttgart (1873 to 1878), 2.4; in Königsberg (1858 to 1865), 1.85; in Birmingham (1873 to 1875), 2.04.

Trismus Neonatorum.—One of the most remarkable points in the geographical distribution of this disease, as compared with tetanus in adults, is the much greater prevalence of the former in the higher latitudes, and even in the extreme polar regions of both hemispheres. This is particularly true of large and populous towns, where most of the deaths from trismus of the new-born are among the poorer classes and in ill-kept foundling asylums. There seems to be but one opinion on the question of race influence upon this disease, and that is that the negro is exceedingly liable to its attacks. In Cayenne this disease produces terrible ravages. According to Hancock, in British Guiana trismus kills upon an average more than half of the children born. In Jamaica twenty-five per cent. of the negro children die each year from it. It is equally destructive in Barbadoes, Grenada, and St. Thomas. In the States of South America trismus is particularly fatal. Bourel-Roncière estimates the deaths from this cause in Rio Janeiro at twenty-five per centum of all the children born. In the city of Buenos Ayres, with a population of 200,000, and an annual increase of 1,000, the deaths from trismus in 1875 were 445, though they have steadily declined since 1880, when they were only 108 for the first six months of the year. Mantigazza witnessed a dreadful epidemic at Monte Video in 1852. In the tropical regions of the eastern countries this disease is fully as severe, notably so in India, Africa, and the Malay Archipelago. It is peculiarly common among the Jewish and Mohammedan children, owing to the traumatism resulting from ablation of the foreskin. According to Wylde (1854) it was common in Ireland. Patema also mentions it as occurring in Italy. In the Dublin Rotunda Hospital the death-rate from 1757 to 1782 was 16 per cent. and most of these were ascribed to trismus neonatorum. It has been endemic in Iceland, where it has caused a frightful loss of life. The Westmannö Islands, off the southern coast, were visited in 1839, and the mortality reached, according to Schleisner, 64 per cent. In New Orleans there were, out of a total mortality of 6,617, 249 deaths from trismus, a rate of 3.7 per cent. Baldwin and Dowell have described its ravages among the negro children of the South. Corson says, "trismus nascentium in the negro is of frequent occurrence as compared to whites. I have never seen a case recover."

Whooping-cough.—The first distinct account of this disease is given by Baillon as occurring in the sixteenth century. The native habitat of the disease is probably very narrow, and does not correspond to its present distribution. In Europe, whooping-cough is found to be pretty generally diffused, though the most fatal forms are found in the northern portion. The Scandinavian countries are great sufferers. In Sweden, from 1749 to 1764, according to Rosenstein, more than 43,000 children died of it, and from 1862 to 1881, 86,000 are reported according to the official returns. It is reported as equally fatal in Norway, Russia, and Denmark. In Prussia, from 1875 to 1880, the deaths reached the appalling number of 85,000. In England and Wales the mortality reports show, for 1848 to 1855, that the deaths were 72,000, and from 1858 to 1867 they were 120,000. The disease is common in Holland, Germany, Belgium, France, and Ireland. In the last-named country, according to Wylde's account (*Edinburgh Medical and Surgical Journal*, 1845), it has the character of an endemic malady, with a mortality that ranks fifth on the list of death causes. During the present century only four cases have been recorded as occurring in Iceland. Finsen, in a practice of seven years, claims to have never seen a case. There have been only three epidemics in the Faröe Islands. Tobler asserts that it has been epidemic in Palestine, and it is known to occur in Greece and Turkey. In India it ranges from the sea-coast up to altitudes of from 6,500 to 8,000 feet. It occurs in Java, Sumatra, and Borneo, as well as in China and Japan.

Australia has been visited by epidemics since 1830, the principal ones occurring in the years 1843 and 1855. According to Heyman and Waitz ("Diseases of Children in Hot Climates," 1851) the disease in the East Indies is found as often among the children of the Malay and Japanese population as among those of the Europeans. Milroy, Mackay, and others speak of its occurrence in India, among the native children, in ordinary terms.

In Africa it has occurred only in a few regions; Mauritius, Madagascar, and Cape Colony, South Africa, the Soudan, and Algiers have had visitations. In Egypt, according to Pruner, it is said to occur among children of every color. Experience shows that this is a disease that possesses little or no regard for either race or country. It occurs in all classes of society, though it seems to be more fatal among the poor than among the rich. The high mortality that appears to characterize the colder countries must be attributed to climatic factors rather than to race peculiarities.

Tetanus.—A noticeable fact connected with tetanus is that the influence of race upon its frequency is well marked. It is more common in all the darker races, and the liability seems to increase in a direct ratio with the depth of color; and while it is comparatively rare in the white race, it is particularly common in the negro. This facts holds good not only for those regions where the dark-skinned races, and especially negroes, have been introduced, such as the Southern States, West Indies, and Brazil, but also for their native seats, as is shown by the general prevalence of tetanus in Senegambia (Thevenot) and other countries of Africa. Swartz mentions the occurrence of tetanus on the West Coast, among the colored population of Cape Colony (Kaffirs in particular); it is found also among the dark races of India and the East

Indies, and among the Indians of Brazil (Sigaud) and the islands of the West Indies. It seems highly probable that this unusual susceptibility depends upon special vulnerability of the nervous system, or upon congenital instability to convulsive disorders in colored races, though some causative factor may reside in the heightened sensibility of the skin; that is to say, there may be a predisposition to be affected by sudden and chilling effects upon the surface. The colored races certainly possess peculiarities in this respect, and when we consider that the circulation (dependent upon continuous exposure to the excessive heat) in the skin is greater in these races, it may be that the differences are explicable upon these grounds.

This latter view is all the more tenable from the fact that even the creoles and acclimated residents in Cayenne, according to Sigaud's experience, are much more subject to the disease than the new arrivals from Europe, who would not have begun to develop that sensitiveness of the skin which always ensues upon a protracted residence in a tropical climate. If we look for another reason for the greater amount of tetanus among negroes, we may find it in the fact that they are much more exposed to the usual causes of the disease, i.e., going about imperfectly clad and barefooted, sleeping on wet ground, and being often wounded in the feet, circumstances that have a large influence in determining the disease. Tetanus is said to be very rare among the opium-smoking Chinese, and according to Bertillon does not occur at all. This people, as a rule, possess very little nervous excitability to any form of disease. Martin, of India, says that the Hindoos are highly susceptible to it. The census shows it to be very common in the rural districts of the Southern States, especially among negroes, being for the males 9.6 and for females 7.3 in each 1,000 deaths from all causes. In Charleston, S. C., it is very high, being in every 1,000 deaths 76.2 for males, and 44.7 for females. On the Gulf coast, throughout the rural sections, it is 32.0 for males, and 29.5 for females. In the city of New Orleans the deaths are, for males, 45.4; females, 44.8; the proportion for the whole of this region being 33.5 for whites, and 59.3 for negroes, in each 1,000 deaths. The extreme contrast to this is found on the North Atlantic coast, where the deaths from tetanus in the rural districts are only 0.7 for females, and 0.2 for males.

EPIDEMIC CEREBRO-SPINAL MENINGITIS.—Until quite recently this disease seems to have been largely confined to Europe; the countries where it has been oftenest seen being France, mostly in the southern part; Italy, particularly in the provinces of Sicily; and Sweden as far north as 63°. It has been prevalent, though slightly and rarely, in Ireland; also in Russia, Denmark (previous to 1848), Hungary, Austria, and Greece; but is absolutely rare in the Iberian Peninsula, Roumania, and Turkey. England has so far escaped with the mildest forms; the Netherlands and Switzerland with very slight and occasional attacks. Belgium, Scotland, North and Central Italy, and Iceland, have as yet complete immunity. The only reference to this disease in the far East is in Syria, Persia, and Asia Minor, although some few cases have been reported from India. The West Indies, Mexico, and Central America seem to be entirely free from it. At the present time, and for a few years past, this country seems to be its chief seat, and it has prevailed from time to time over every portion of the United States. The first outbreak occurred in 1814 in the New England States, and lasted until 1816. The remarkable fact associated with this epidemic was that it occurred almost wholly among children, the different outbreaks since showing many differences in this respect. With regard to the susceptibility of the different races, it is said that at the time of the first outbreak of the disease in Algeria the Arabs suffered as severely as the whites.

In several of the epidemics of the Southern States the negroes have suffered with particular severity. Of 85 patients treated by Ames, of Alabama, 22 were whites and 63 were blacks. In the New Orleans epidemic of [illegible] Faget says the negroes suffered the most, and it was chiefly among them that the disease was found. The same is true of the disease in Memphis, Tenn., during the outbreak among the colored troops in 1862-63. In the "Transactions of the Mississippi Medical Congress, 1878," Hughes calls attention to the unusual susceptibility of the negro race in the Mississippi epidemic of 1862-63, in the Maryland one of 1864, and in Mobile in 1864-65. Williams, of Montgomery, found that during the epidemic of 1848 out of 84 patients 10 were under ten years, 23 between ten and twenty, 27 between twenty and thirty, the remainder being between thirty and forty years of age. At the time of the occurrence of the disease in Philadelphia, in 1867, Guthrie says that it was severe in the negro.

MALARIA.—This is a disease of all times and peoples. The predisposition to it is highest in Caucasian races, not only in Europe, but also among the Arab population in the Barbary states and in India, where the Mohammedans and Hindoos suffer to the same degree as do foreigners. This is not less true for the Malays and Mongolians, and also for the Indians of North and South America. The tendency seems to be less in the Ethiopian races than in others (though this is limited to particular localities), which, however, do not enjoy complete immunity, though they are as a rule less frequently and less readily attacked than other people.

For this statement we have the experiences of Thevenot in Senegambia, and of Daniell for the West coast and for Nubia, and also the testimony of others, equally reliable, for other parts of Africa, as well as for malarious regions of the world to which negroes have migrated. There are some reasons for supposing that this immunity is an acquired one rather than congenital, as may be learned from the number of deaths among children. The predisposition is lessened or becomes weaker in proportion to the length of time that the individual is continuously exposed from birth to maturity. That this exemption may be entirely lost again, is fully exemplified by the history of the negroes in the South, who, previous to the late civil war, were remarkably free from malarious influence; but now, through the changes incident to freedom, cares, intemperance, and alterations in life generally, they are peculiarly liable to it, the death-rate being 48.3 per 1,000, from all causes, for blacks and only 30.7 per 1,000 for whites.

Trotter says that, "the constitution of the negro, whether of African or American birth, requires an habitual residence in Africa to be exempt from the fever of that country." Some authorities have denied that there can ever be such a thing as acclimatization in a malarious region, since this is peculiarly the very disease in which one attack always gives a predisposition for the recurrence of another. But that continuous exposure does have some influence in keeping off or mitigating the disease can scarcely be denied or refuted, since it is known that those who are born and live amidst it with impunity, will, if they leave their native country for a season, suffer from it upon their return.

In the malarious districts of Europe, the indigenous population sicken much less frequently than people who come there from regions free from malaria. In India the type of the disease appears to be altered with regard to the natives and Europeans, being for the former paroxysmal in character, and for the latter continued, and often associated with grave cerebral affections. In Costa Rica, says Frantzius, "the severe forms of malarial sickness occur among the blond-haired and blue-eyed Europeans and the residents of the cooler regions of the highlands, while the settlers and acclimated are affected but little; the negroes and mulattoes showing the greatest resistance of all."

Barat says of the severe malaria of Mauritius, that the Kaffirs and Malagasys suffered less than any others. The malaria of China is prone to take on a typhoid type ("Report of Medical Mission of China," 1888).

TYPHOID FEVER.—This is now known to be a ubiquitous disease, although until quite recently the tropics were considered to be free from it. There seems to be unanimity among observers that the immunity acquired through acclimatization is more perfect in tropical and subtropical regions than in the higher latitudes.

Bryden has conjectured that high temperature predisposes the newcomer to the disease in India. This same observation has been made with regard to those newly arriving in New Caledonia, where it is stated that the natives are totally exempt from typhoid fever. It is said that the Arabs of Algeria are scarcely ever attacked, though the disease is both common and fatal among Europeans resident there. This disease is rarer and milder in lower latitudes than in higher, but whether this is to be attributed to climatic factors rather than to others remains to be proven. The influence of race is manifested in this disease to the extent of the negro being less liable than the white; this is especially true as regards the former in their natural habitat, though change of residence is known to extinguish this protection and bring about susceptibility.

Tidyman (*Philadelphia Medical and Surgical Journal*, 1826) calls attention to the frequent occurrence of typhus (typhoid) fever among the negroes of the Southern States, who at that time were free from malarial influence. Of forty-three cases of typhoid fever treated by Sutton, of Georgetown, Ky., in 1846, thirteen were among negroes. Lewis says that hundreds of negroes died in the winter of 1835–36, of this disease, in central Alabama; and Gaston (*New Orleans Medical Journal*, 1844) speaks of its frequent occurrence among the negroes of South Carolina.

The influence of class is seen in this disease in that those of the higher walks of life are less susceptible, though when attacked they suffer the most. During the year 1885, the death-rate from typhoid fever was found to be, in each one hundred thousand of population, as follows: Paris, 63; London and Berlin, 17; Vienna, 14, and Marseilles, 149. In the year 1887, the mortality from this disease was stated to be, in each 1,000 deaths from all causes, as follows: London, 46.8; Dublin, 16.05; Paris, 17.06; Berlin, 44.0; Geneva, 23.8; Vienna, 20.9; St. Petersburg, 29.0; Lisbon, 14.5; Cairo, 38.8; Philadelphia, 28.8, and New York, only 8.01.

The tenth census gives the mean age of death for this country at twenty-seven years. The rate among each 1,000 deaths from all causes is 30.19. In comparing the rural and urban sections, the mortality for the former is given at 36.0, and for the latter at 16.7, indicating that this is not altogether a disease dependent upon sewerage and filth. Figures relative to the mortality in the different races show that the whites have a death-rate of 33.9, and the negroes one of 31.7 per 1,000 deaths from all causes. The Irish show a smaller, and the Germans a larger, death-rate than the average for the whole country. In its geographical distribution typhoid fever is found to be especially common in the central States, and also in those of Georgia, Tennessee, North Carolina, Alabama, and Texas.

Yellow Fever.—Measured by its range over the earth, yellow fever holds a low rank among infectious diseases. This limited area necessarily limits the study of its comparative features, still there are sufficient data to enable us to distinctly discern the influence of race and nation upon its phenomena. The early history of this disease is involved in obscurity, and the first reliable account comes from the middle of the seventeenth century. The distribution of yellow fever extends, in the Western Hemisphere, from 35° 54′ (Montevideo) south latitude, to 44° 39′ (Halifax) north latitude. In the Eastern Hemisphere it goes from 8° 48′ south (Ascension) to 51° 37′ (Swansea) north. Regarding the manifestation of susceptibility among the different nations and races, there is one prominent feature, and that is, the newly arrived stranger, in a yellow fever district, is the one most liable of any; and this is found to depend somewhat upon nationality and the distance of his former residence from the equator. Under this heading we have the careful data obtained by Barton upon each 1,000 deaths in New Orleans, in the year 1853:

Native Creoles		3.54
Strangers from	West Indies, Mexico, and South America.	6.14
" "	Southern United States	13.22
" "	Spain and Italy	22.06
" "	Middle United States	30.69
" "	New York and New England	32.83
" "	Western States	44.23
Strangers from	France	48.13
" "	British America	50.24
" "	Great Britain	52.19
" "	Germany	132.01
" "	Scandinavia	163.26
" "	Austria and Switzerland	220.08
" "	Netherlands	328.94

Blair states, from his experience in Guiana from 1837 to 1845, that "the lower the isobar in the native country of those attacked, the more severe the sickness, so that, while the mortality among the West Indians amounted to 6.9 of those sick, it arose to 17.1 in the Italian and French, 19.3 in the English, 20.2 in the German and Dutch, and for the Russian and Scandinavian it was as high as 27.7."

It has been considered a matter of doubt whether there was anything like congenital immunity due to peculiarities of race. So far as this pertains to the white race, there seems to be little reason for further entertainment of the question. While the relative immunity that the creoles enjoy is a fact, yet this can be reasonably referred to acclimatization, and partly also to the circumstance that they might have had the disease in childhood, and have thus acquired immunity. Concerning the colored races, the question is not so easily determined. There are so many remarkable occurrences, associated with the negro and yellow fever, that point to his being protected in some manner, that we are forced to conclude that he does possess some congenital immunity. That this is born in him, and not acquired, may be inferred from the fact that the same exemption occurs wherever he exists, and even when he has not been acclimated, and it is more pronounced in those that possess the racial characteristics the strongest. A noticeable fact connected with the outbreak, in 1888, at Jacksonville, Fla., was that thirty-eight cases occurred among the whites before a single negro was attacked.

Daniell says of the epidemic in Savannah, 1820, "that not a single case occurred in three hundred blacks that had just been imported."

Nott, who attended through five epidemics at Mobile, never had a case in the pure negro, though he saw two or three in mulattoes.

Fenner says that the least mixture of the blood of the white race produces liability, and this is directly proportional to the amount of white blood. He further states: "It is a well-established fact that there is something in the negro's constitution which affords him protection from yellow fever." Doughty expresses himself to the same effect: "In the natural African the constitution appeared to me as secure against yellow fever as a person who has had small-pox is against its recurrence." These opinions are amply corroborated by the learned Dickson, Moultrie, Arnold, Leblond, and Curtis. Blair says of the epidemic of 1852 to 1853 in Guiana, of 7,890 negroes not one had the fever. Of the 500 negroes from the Nubia and Soudan regions, which are free from fever, who went to Mexico with the French army, not one had the fever; whereas the French and Mexicans were decimated by it. The American Indians, those of Mexico and Brazil, and the Coolies (Hindoos), according to Kerhuel, in Cayenne, have no immunity.

On the other hand, the Mongols, like the negroes, are more or less exempt. "The Chinese," says Eysaguire, "settled in Lima, are like the native negroes, almost exempt from the disease."

Dengue.—This is a peculiarly tropical malady, being limited to places on the coast between 32° 47′ north latitude, and 23° 23′ south latitude. It manifests an almost absolute independence of circumstances of race, nationality, sex, and age. Only a few observers, such as Squaer, Maxwell, and Stedman, in the West Indies, have found that the negro had the sickness more rarely or more mildly than other races. In the Java epidemic, in 1872, according to De Wilde, that race enjoyed an almost complete immunity. In the instance of the epidemic at Benghazi, Pasquar says, "it was notable for the remarkable immunity experienced by the blacks;" but he adds, that this race at the time had no exemption in Egypt, Senegal, or elsewhere.

Christie is also of the opinion that the natives of Zanzibar suffered less than the Europeans. On the other hand, Kennedy, of Guzerat (1828), and Manson and Müller, at Amoy (1872), met with more numerous and more severe cases among the natives than among Europeans. In Cochin China, according to the opinion of Breton, cases of dengue sickness were much more frequent among the Annamese part of the population than among the Chinese.

Wise, in the Dacca epidemic of 1872, appears to have detected a peculiar predisposition to dengue in persons who were suffering from surgical disease. According to [illegible], children enjoyed a certain exemption in the Mauritius epidemic of 1873. These conflicting reports are of such a nature as to leave the question of race susceptibility in a very unsettled condition.

In Lallemand's account of the disease at Rio de Janeiro, 1846–47, he says, "on the *fazenda*, whole gangs of negroes fell ill, ships were abandoned, and schools deserted."

In Calcutta, during the epidemic of 1871–72, the number of cases was estimated at seventy-five per cent. of the whole population, the disease being first developed among the Jews, and the poorest and those living in the most densely populated parts of the town. Maxwell says, concerning the epidemic at Jamaica, that "almost the whole population, both white and black, were affected sooner or later." In 1818, only a few of the seventy thousand inhabitants of Lima escaped.

PUERPERAL FEVER.—This disease, as a rule, seems to be one that primarily occurs among civilized and thickly crowded populations of the higher latitudes. According to Peschel, a European woman in the Dutch possessions in India reflects maturely before she consents to marriage, for the first childbed usually costs the life of the mother. Rowley, the English missionary, says "even the Portuguese women at Tete, on the Zambesi, succumb to this dread fatality." Sir Ronald Martin, speaking of India, gives his experience as follows: "Puerperal fever I never saw in Calcutta, and I remember very few instances of children born dead." However, others equally deserving of confidence have stated that puerperal fever occurs here in its worst types. Dr. Clark observes that on the coast of Coromandel "parturition is not attended with such great danger as in Bengal, neither is puerperal fever of such a putrid nature." The London *Lancet*, for 1845, says that in Australia and New Zealand the disease is quite rare. In South America it visited Montevideo, in 1875, with a disastrous epidemic. Turkey, and Constantinople in particular, is said by Rigler to have less puerperal fever than any part of Europe, yet the disease does occur there sometimes. It is said to be very rare both in Iceland and Greenland. In the populous parts of this country it is equally as common as in Europe. It is very rare in Central America and the West Indies. Africa is said by only one authority (Pruner) to be visited by it, and this in Egypt, where it is both slight in degree and uncommon. In India, according to Webb,[2] it is by no means infrequent among Hindoo women, in whom it prevails often to a great extent.

ERYSIPELAS.—The occurrence of this disease among the various races is attended with some marked peculiarities. The continent of North America seems to be the particular seat for epidemics, having been visited by seventy from 1822 to 1880, the territory invaded extending from Louisiana to Greenland. Holmes says (1854): "Nearly every year we hear of it either in Michigan, Wisconsin, or Minnesota. It also occurs in the wet, cold spring months in Louisiana and Texas." Seven of these epidemics were in New England, and eighteen in the eastern central States. This disease has been in the past limited to the temperate zones of both hemispheres.

We have various accounts of its occurrence in the warm and subtropical climates of Turkey, Asia Minor, Syria, Persia, Algiers, and Egypt. It has visited Iceland, Greenland, and the Faroe Islands, according to Martins and Lange. Whether the purely tropical climates are exempt from erysipelas, as has been claimed, is still a debatable question, and conclusions on this point should be drawn with great caution. Coindet[1] says he did not see a single case during seven years of practice in Mexico. Carlisle is reported as knowing of only one case in a practice of five years at Zanzibar. MacKinnon and other authorities of India say that it is a rare disease in those regions, though Annesley and Morehead say that traumatic erysipelas is sometimes common enough to become an epidemic. Material available for correct conclusions regarding the influence of race upon this disease is very meagre, and there seems to be much confusion in its classification. Tschudi says that it is much more common in the "Puna" regions of Peru (inhabited by Indians) than in the Eastern Slopes.

CHOLERA.—It is a matter of difficulty to estimate the influence of race and nationality upon this disease. The elements that enter into a mixed population are very variously circumstanced as to food, drink, habitation, and living in general. However, there seem to be some grounds for the common belief that the negro race is in greatest danger from the disease. Christie, in the London *Lancet*, 1871, says, from his experience on the east coast of Africa, that this was the case there. At Durban and Mauritius authorities say the same. With reference to Reunion, Petit and Vinson say: "On the east coast of Africa the mortality is 6.5 per cent. in the Hindoo population, 10 per cent. in the Arab, and 25 per cent. among the negroes." Again, Beaugendre says of Mauritius, in 1819, that "twenty-two thousand negroes died in two months; likewise in 1854 the African race presented by far the largest contingent to the sick-list and death-rate." At this same place and time, the Chinese who were present suffered only in isolated cases, notwithstanding that they lived in the districts chiefly affected.

The report of Petit, of Reunion, in regard to the epidemic of 1859, says: "They fell down (the negroes) in a stupor, as if they had been paralyzed . . . . Men who were in full vigor and life immediately before were prostrated in the course of three or four hours." In the Dutch East Indies, during the epidemic of 1873, the mortality among the natives was 35.3 per cent. of the sick, and among the Europeans 51.5 per cent., while it was nearly 60 per cent. among the negroes. In Ceylon, 1859–67, an average of 4.9 sickened in every 1,000 troops (Europeans), and 2.38 died, while the numbers among the negroes were 8.7 and 4.87 per 1,000.

According to Walther[3] the proportion of deaths among the population of Guadeloupe, during the epidemic of 1865, was as follows: Chinese, 2.7; Hindoo coolies, 3.26; whites, 4.31; mulattoes, 6.32; and negroes, 9.45.

In the United States Army, in 1866, of the white troops, 77 in each 1,000 were attacked, while of the blacks 135 per 1,000 suffered. Anglo-Indian physicians have made some very conflicting reports regarding the occurrence of cholera among the Hindoos as compared with the Europeans. By Bryden and Cunningham, the statement is made that the disease was more common among Europeans stationed in India than among the Sepoys, but there are reasons to think that these differences are due to their mode of life, which is more simple and temperate than that of the English, rather than to race peculiarities. From 1861 to 1870 the mortality in Bengal was, for Europeans, 2.12 per 1,000, and for Sepoys 4.27 per 1,000. In Punjab it was for Europeans 5.63 per 1,000, and for Sepoys 1.63, showing quite a contrast in different localities. There seems to be no question but that the type of the disease is the same in both these localities and among both people.

All observers are in accord with the statement that the natives of Lower India, including Siam, Annam, and Burmah, suffer much less from cholera than the European settlers. As to the question of individual resistance, it has been found that this is directly proportional to good hygiene and cleanliness, experience showing that groups and classes of population suffer in a direct ratio to the unhealthfulness of their surroundings.

J. Wellington Byers.

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[1] [illegible] Mexico, [illegible].
[2] Pathologia Indica, 1848.
[3] Archives de Médecine navale, 1869.
[4] Gazette des Hôpitaux, August, 1880.
[5] Hygiène des Pays chauds, 1848.

REPRODUCTION. To the growth of every organism there is a definite limit, and until that limit has been reached or approached the material gained by the organism by the assimilation of food-stuffs is applied to its increase in size; but as soon as this normal limit of size is approached there supervenes a tendency toward a separation of a portion of protoplasm to form a new individual, more or less similar to that from which it had its origin. In this way extinction of the species is guarded against, and this process of separation from the parent of a portion of its substance capable of leading a more or less independent existence is termed Reproduction.

Among the most simple forms of life the various modifications of the reproductive process may be reduced fundamentally to such a simple separation of a portion of the tissues of the parent as has been indicated above, and there is no question of a union of two elements, or *gametes*, to form a single descendant. In forms a little higher in the scale of life there is, however, such a union, and since in this process there is required the co-operation of two elements, and a more or less perfect distinction of sex is indicated, it is termed the *sexual* method of reproduction, in contradistinction to the more simple method, which is known as the *non-sexual*, or *asexual*.

There can be no doubt but that the non-sexual method is the more primitive of the two, but even in forms of a relatively very low grade of organization the sexual method occurs, and as one ascends the scale, both in plants and in animals, one finds it becoming more and more important, until, finally, as a means of perpetuating the species it entirely supplants the more simple method. In the majority of animals and plants, however, both processes occur, and even in the highest forms the non-sexual method is to be observed in the individual cells of which they are composed, not, however, strictly speaking, as a process of reproduction, but simply as a mode of growth. In multicellular organisms a process termed the "physiological division of labor" occurs in all but the simplest forms; the various cells composing such an organism do not all retain all the functions which a simple unicellular organism presents, but certain cells take upon themselves one principal function, losing to a greater or less extent the power of fulfilling the others. Thus certain cells assume the function of assimilation for the entire organism, disregarding the other functions, such as respiration, motion, sensation, reproduction of the species, etc., which are respectively performed by other groups of cells. Thus these various cell-groups, or organs, each with a different function, are dependent one upon the other, and are united to form an organism whose vital activity is the sum of the vital activities of its component organs. Now the function of reproduction of the species is assigned to, or assumed by, certain definite organs, known as the ovary in the female and the testis in the male; but the individual cells of the other organs retain, for a time at least, the power of non-sexual reproduction, whereby new cells, similar structurally and functionally to those from which they originated, are produced, and the organ and the organism thus increase in size, or grow.

Growth, in fact, in such multicellular forms, depends essentially upon the increase of the number of cell elements of which the organism is composed, this increase being brought about by the division, *i.e.*, the non-sexual reproduction, of the cells already present. The difference between growth and reproduction lies simply in the fact that in the former the newly formed cells do not separate themselves from their fellows and lead independent existences, but remain in organic connection with them and with each other (see article on Segmentation). Hence reproduction has been well defined as discontinuous growth.

Non-sexual Reproduction, or Agamogenesis.—This method of reproduction is essentially the division of the parent organism into two or more parts. In unicellular forms the new parts formed are necessarily also unicellular, but in multicellular organisms the parts separated off may be multicellular and include cells from various regions of the body. The process is best illustrated, however, by what take places in unicellular organisms, or by cases in which a single cell of a multicellular structure reproduces independently.

The simplest form of the process is that of *fission*, or *division*, in which the parent cell splits into two equal or nearly equal daughter-cells. This is the commonest form of non-sexual reproduction, and can be well seen in many unicellular organisms, both animal and vegetable. It may be observed, for instance, in the Monads, in the Infusoria, etc., among animals, and in the Bacteria and many other unicellular Protophytes among plants. It is also the method usually followed in the multiplication of cells occurring during the growth of an organism, and can be readily observed in the developing ovum of many animals (see article on Segmentation). In a cell about to undergo division remarkable changes in the protoplasmic contents usually occur, affecting principally the cell-nucleus, which, after passing through a series of usually definite changes in appearance, shape, and arrangement of its constituent molecules, finally divides into two parts, which separate from each other, and following this division of the nucleus a division of the rest of the cell takes place. This is well seen in Fig. 5019, which represents a unicellular animal, *Amœba polypodia*, in various stages of fission.

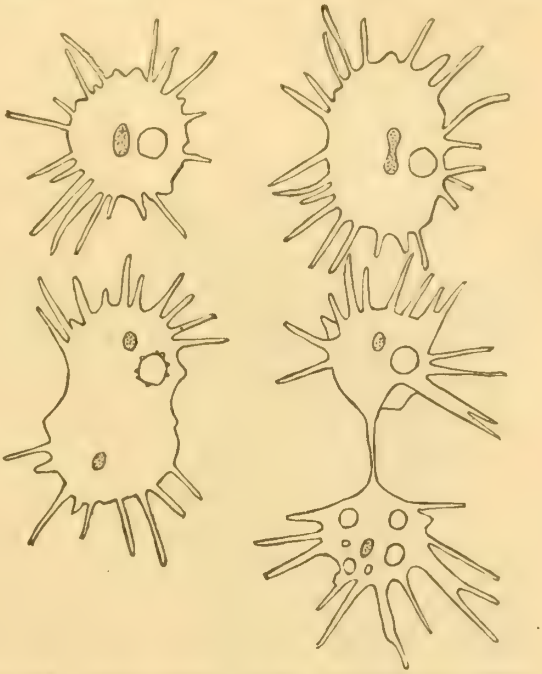
FIG. 5019.—Amœba polypodia, M. Sch. Reproducing by division. (After F. E. Schulze.)

The other modifications of non-sexual reproduction may be regarded as variations of the fission process, differing only in the manner in which the division takes place. *Gemmation*, or *Budding*, includes a number of cases in which the part to be separated forms at first as a small outgrowth from the body of the parent, which outgrowth, gradually increasing in size, is finally constricted off from the mother-cell. A good example of this is afforded by the yeast plant (*Torula cerevisiæ*) as shown in Fig. 5020, which represents a stage in the reproduction of that plant. Not unfrequently, however, the bud does not separate from the parent, but remains more or less intimately connected with it, a colony being thus produced. In multicellular organisms this frequently occurs, the gemmæ,

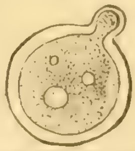
FIG. 5020.—Torula Cell. Reproducing by budding.

or buds, giving rise to more persistent individual members of a colony, and being usually multicellular also. The buds which give rise to the branches of trees are examples of this, since a tree may be considered a colony of [illegible], and among animals the Hydroids, Corals, Polyzoa, and Tunicates furnish numerous examples of the same process.

Endogenous cell multiplication constitutes another modification of the non-sexual method, consisting of the separation of the protoplasmic cell contents into a number of parts. The process of separation is not, however, division in the typical sense, but consists of the formation in the protoplasm of a cell of a number of centres of aggregation, which may or may not be represented by a nucleus, and around each of which a portion of the protoplasm collects, forming a cell. This method is well exemplified in certain Fungi belonging to a group termed the Ascomycetes.[5] Peziza, the common Cup-fungus, may be taken to illustrate the process (Fig. 5021). The non-sexual spores are formed in club-shaped cells termed asci, arranged in a layer, usually brightly colored, upon the concave surface of the cup-like structure. These asci when first formed are densely filled with granular protoplasm which contains a single nucleus (Fig. 5021, *a*). This soon disappears, its substance being distributed throughout the protoplasm, which becomes richly vacuolated (*c*). Centres of aggregation (usually eight in number) soon make their appearance, being in some cases preceded by the formation of nuclei, one for each centre, and around these the granular protoplasm collects to form eight oval spores or cells, which form for themselves cell walls, and are liberated by the rupture of the original ascus wall.

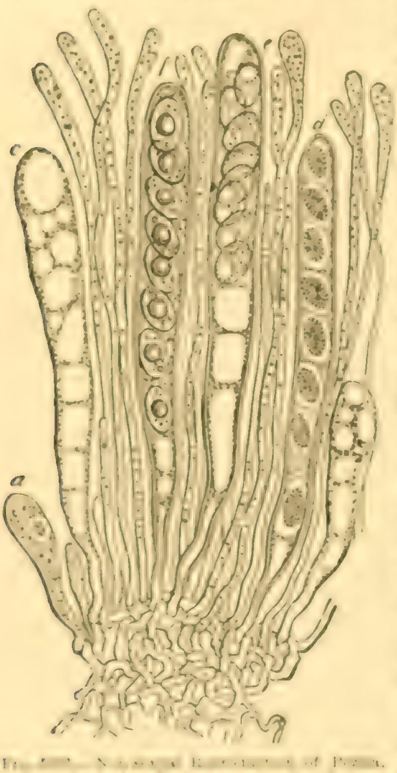

Fig. 5021.—Non-sexual Reproduction of Peziza. (From [illegible].) *a*, Young ascus; *b*, *c*, *d*, *e*, *f*, stages in formation of ascospores.

Among animals this process is not so frequent as in plants, but nevertheless it is to be seen in some forms. The spore formation in some of the unicellular parasitic Gregarinida appears to be to a certain extent at any rate a process of endogenous cell formation, and in the closely related cell parasites, the Coccidia, it is of the same nature. Among the latter there are some interesting examples presenting a series of stages between ordinary fission and the simultaneous formation of a number of cells from the mother-cell protoplasm, *i.e.*, endogenous cell multiplication. The number of spores formed by the Coccidia is in direct proportion to the size of the individual, the larger the mother-cell the greater the number of spores. In the genus *Eimeria* the contents of the encysted mother-cell form a single spore which surrounds itself with a delicate wall, while in *Klossia* and *Isospora* the number of spores formed by each mother-cell is increased to two, formed by a single process of division, and in *Coccidium oviforme* from the epithelial cells of the gall-duct and intestine of the rabbit,* four spores are formed, probably by a simultaneous division of the contracted protoplasmic contents of the encysted mother-cell. Finally, in other larger forms, such as that which occasions relatively large cysts in the kidney of the frog, a considerable number of spores are formed by endogenous cell multiplication.

The case of *Coccidium* is especially interesting. What occurs in that form may be regarded as a case of acceleration of ordinary fission, and many cases of a similar nature might be referred to. For instance, we know that in the segmentation of an ovum the various phases of division appear regularly in sequence, the ovum dividing at first into two parts, each of these then into two more, and so on. In the ova of the Cœlenterate *Renilla* E. B. Wilson has observed a remarkable departure from the normal sequence of the divisions, the ovum at once separating into eight, sixteen, or thirty-two cells, the intermediate stages being omitted, and Brooks has observed a somewhat similar acceleration, not carried, however, quite so far, in the ova of the American oyster. It is unnecessary to draw attention to the similarity of these cases to that of *Coccidium*. They serve to indicate the relation which endogenous cell multiplication bears to ordinary fission.

Encystment.—Before leaving the subject of non-sexual reproduction, attention must be called to a process which frequently accompanies, or rather precedes, this mode of reproduction, especially in unicellular forms. It is the phenomenon of encystment, consisting of a rounding off and contraction of the protoplasm of which the individual is composed, followed by the formation of a wall or cyst, more or less resistant and non-conductive, within which the organism remains for a greater or less length of time in a resting condition (Fig. 5022). It does not seem likely, however, that encystment had originally any connection with reproduction, but occurred under widely different circumstances, either (1) for the protection of the organism and the preservation of its existence when subjected to unfavorable or injurious conditions, such as lack of food, moisture, etc., or (2) when the organism had been supplied with and had ingested a large amount of nutritive substance and entered into a resting stage for the purpose of more rapidly and efficiently assimilating the food stuffs, the cyst being formed perhaps as a protection from enemies.

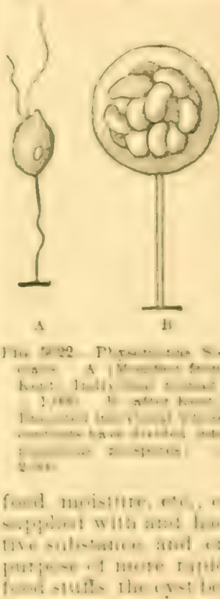

Fig. 5022.—Physomonas Socialis. A, [illegible] (Kent); [illegible]; B, after having become encysted and [illegible] contents have divided into [illegible] zoospores. [illegible]

It is perhaps in connection with the latter case that encystment has become so frequently a prelude to reproduction. Lack of nutrition results in the impairment of the reproductive processes, and, conversely, abundant nutrition favors proliferation. A well-nourished organism which has entered its resting stage is assimilating the food stuffs it has ingested without any such loss or expenditure of energy as it would suffer were it actively moving about, and is consequently under most favorable conditions for reproduction. Hence has arisen the association of the two processes. It must be observed, however, that division is not invariably the direct sequel to encystment, even when the latter is the result of an excessive supply of food stuffs. It may happen that after remaining in this resting stage for some time the organism will finally issue from the cyst in a form similar to that which it possessed before being enclosed, but better nourished and rejuvenated, and reproduction by division may then take place. Such a process only serves, however, to substantiate the theory that encystment and reproduction are not phenomena originally dependent upon each other.

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* The Coccidium which occurs in the liver cells of man is probably identical with this, as are forms occurring in several different kinds of [illegible].

Sexual Reproduction, or Gamogenesis.—Sexual reproduction consists in the formation of two kinds of reproductive cells, a union of which is necessary for the development of a new organism. In the simplest forms of the process there is no differentiation of the two cells, so that one can readily be recognized as the fecundating and the other as the fecundated cell, but both the elements are essentially similar. This simple form of the process is known as *conjugation*, and is well represented in some of the lower plants, for instance in the genus *Spirogyra*. This consists of filaments usually occurring in masses of a bright green color in stagnant water, each filament being composed of a number of elongated cells placed end to end, and characterized by the green coloring matter, chlorophyll, being arranged in one or more spiral bands. When about to conjugate, processes grow out from the walls of the cells of adjacent filaments (Fig. 5023, *a*), which, increasing in length, finally come into contact (Fig. 5023, *b*). By the absorption of the cell wall of each process at the point of contact, a canal uniting two cells is formed. In the meantime the contents of each cell engaged in the process have contracted to a rounded mass, and after the establishment of the connecting canal one of these masses flows over through the canal into the other cell, and unites with the protoplasmic mass with which it comes into contact there (Fig. 5024, *A*, *a*). The single spore so formed surrounds itself with a more or less dense wall (Fig. 5024, *B*), and after remaining for a length of time in this condition germinates, if circumstances be favorable, and develops into a Spirogyra filament similar to those from which it arose.

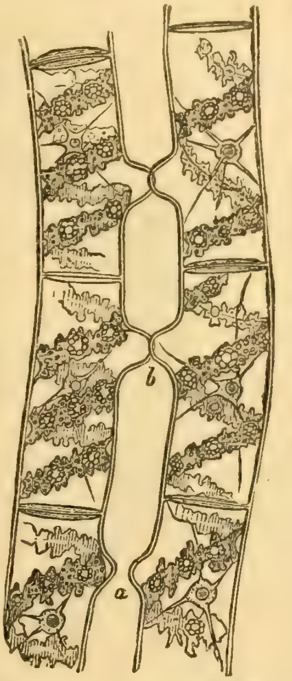

FIG. 5023.—Conjugation of Filaments of Spirogyra longata. *a*, Beginning of formation of processes; *b*, the processes in contact. (From Sachs.)

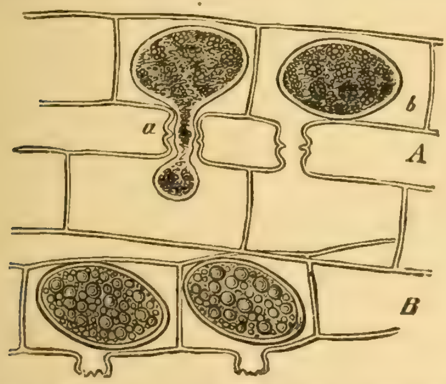

FIG. 5024.—Conjugation of Spirogyra longata. (From Sachs.) *A*, Protoplasm passing from one cell to the other at *a*; *B*, spores resulting from conjugation.

In the majority of cases, however, there is a well-marked difference between the two uniting bodies or *gametes*, as they may be called. One is termed the female gamete or ovum, and is the larger fecundated cell, usually incapable of motion; while the other, the male gamete or spermatozoon is, as a rule, much smaller, and capable of active movement, and is the fecundating cell.

Among animals the ova and spermatozoa are formed at certain definite points by the modification of certain cells of the germ layers. Among the cœlenterates, the ova cells are derived, in some cases, from the ectoderm, and in others from the endoderm; but in higher forms it is usually certain cells of the mesoderm which assume the reproductive function, being aggregated into definite masses, termed the ovaries or testes, according as they are female or male. The gametes when mature are, in the majority of cases, dehisced into the pleuro-peritoneal cavity, and make their way to the exterior by ducts, usually specially modified portions of the excretory apparatus. In most cases the ova are fertilized after they have reached the exterior, though frequently the union of the two gametes takes place within the body of the female parent.

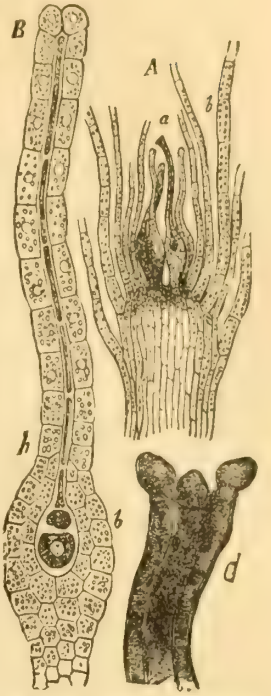

FIG. 5025.—Female Reproductive Organs of Funaria hygrometrica. (From Sachs.) *A*, a cluster of archegonia (*a*) at apex of stem, surrounded by leaves (*b*); *B*, archegonium magnified; *C*, apex of fertilized archegonium.

In plants possessing well-marked male and female gametes, as, for instance, the mosses, the male gametes are minute mobile bodies developed in the cells of a special organ, known as an antheridium (Fig. 5026, *A*). This consists of an external envelope formed of a single layer of cells, and an internal mass of cells in which the male gametes are formed. When these are mature the walls of their parent cells break down and disappear, and the gametes are thus set free in the interior of the antheridium, and on the bursting of its outer envelope they pass to the exterior. The female gamete is enclosed in a special, usually flask-shaped organ, the archegonium (Fig. 5025), which likewise consists of an external envelope enclosing a single axial row of cells. The lowermost of these becomes the female gamete, and the others finally degenerate and are transformed into a mucilaginous mass filling the neck of the flask, through which the male gametes make their way to come into contact with the female element. Only a single gamete is thus formed in each archegonium, while the number of spermatozoids in each antheridium is usually very great.

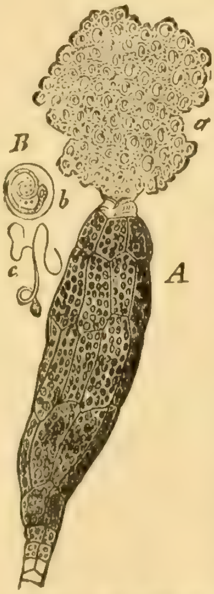

FIG. 5026.—Male Reproductive Organ of Funaria hygrometrica. (From Sachs.) *A*, antheridium; *a*, the male gametes escaping; *B*, a male gamete enclosed within the parent cell, *b*, and free, *c*.

The arrangement just described may be regarded as typical for plants, but in the higher forms, the gymnosperms or cone-bearers, and angiosperms, or flowering plants, many complications have arisen which will be alluded to under the heading of "Alternation of Generations," but for the detail the reader must be referred to botanical text-books.[6]

The Relation of Sexual to Non-sexual Reproduction.—At first sight it would seem that these processes were quite distinct one from the other, and could have no connection with each other. By studying the reproductive processes exhibited by the lower forms of life, a very gradual passage from one to the other can, however, be observed, and an account of some of these processes, both in plants and in animals, will be given.

In discussing the modifications of non-sexual reproduction, no mention was made of the fact that the newly formed cells or spores are in many cases slightly different from the parent cells which give rise to them, the difference consisting in the possession by the progeny of protoplasmic processes termed flagella, by the movement of which locomotion is possible. The simplest mode of formation of these motile zoospores, as they are termed, is to be seen in a unicellular plant, *Protococcus*, common in moist situations, which in its non-motile condition consists of a minute spherical mass of protoplasm having intermingled with it green or red coloring matter, and provided with a nucleus and a cell-wall composed of cellulose—a typical plant-cell in fact. It reproduces rapidly by division under favorable conditions, forming patches sometimes covering comparatively large areas, and under certain circumstances passes into a motile stage. The protoplasm withdraws itself from the cell-wall and develops two long flagella, and by the bursting of the cell-wall the entire contents are set free as a motile zoospore (Fig. 5027, *b*) which, after swimming about for a while, settles down, absorbs its flagella, forms a cell-wall around itself, and returns to the resting stage from which it originated.

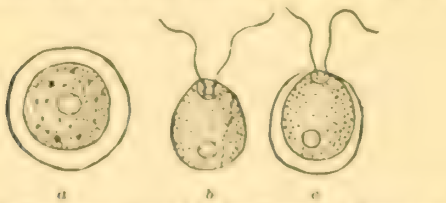

FIG. 5027.—*Protococcus.* (*a* and *b* after Howes.) *a*, Resting stage; *b*, zoospore; *c*, zoospore before it has left the cell-wall.

This process cannot strictly be termed reproductive, but is probably for the purpose of dissemination of the individuals composing a group which is enlarging unduly in proportion to the amount of nutrition obtainable in the locality to which it is confined. By means of the zoospore stage individuals are enabled to wander some distance from their fellows, and so all are relieved from a too intense struggle for existence.

In many cases, however, this formation of zoospores is associated with reproduction by division; as, for instance, in the filamentous alga known as *Ulothrix*,[7] which occurs frequently in considerable quantities in fresh-water ponds and streams. Each plant consists of a green filament, composed of a number of cells arranged in a single row, the basal cell being modified to form an organ of attachment. Each cell of the filament may be compared to a *Protococcus* cell, the entire filament being equivalent to a filamentous colony of protococci. The process of fission is limited to growth, the new cells formed by this process not separating and leading independent existences, but remaining in connection and so producing an increase in the length of the filament. The reproduction consists of the formation of zoospores. In certain cells of the *Ulothrix* filament the entire contents become converted into a single large zoospore with four flagella (Fig. 5028, 2), the process being in this case similar to what occurs in *Protococcus*, but in other cases the cell contents divide into two, four, eight, sixteen, thirty-two, or more parts (Fig. 5028, 1 *b, c, d, e*), each of which becomes a zoospore, the smaller ones or micro-zoospores, *i.e.*, those formed by the division of the cell contents into sixteen or more parts, differing from the larger macro-zoospores, in addition to their size, in having only two flagella instead of four (Fig. 5028, 3 *a*). After swimming about for a while, the macro-zoospores settle down, withdraw their flagella, and germinate, producing a new *Ulothrix* filament. Some of the micro-zoospores do the same, the growth of the resulting filaments being, however, slower than in the case of the larger spores; but—and this is the important point—a considerable number of the micro-zoospores conjugate (Fig. 5028, 3 *b, c*) with others before settling down, the resulting spore (zygospore) producing a filament stronger than that which arises from a single micro-zoospore.

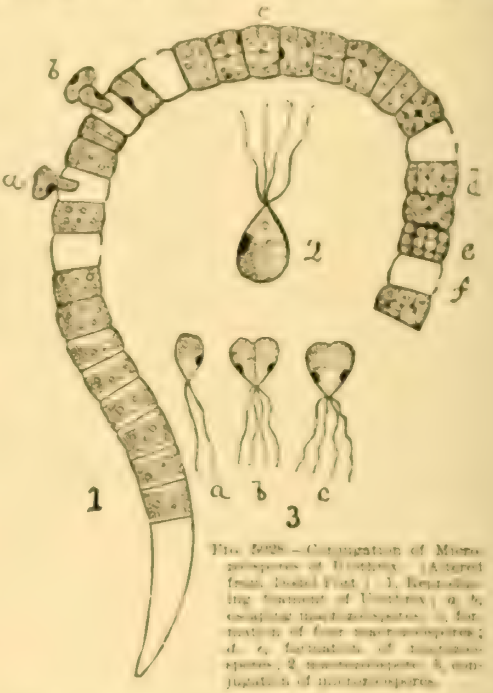

FIG. 5028.—Conjugation of Micro-zoospores of Ulothrix. (Altered from Dodel-Port.) 1, Reproducing filament of Ulothrix; *a, b*, escaping large zoospores; *c*, formation of four macro-zoospores; *d, e*, formation of micro-zoospores; 2, macro-zoospore; 3, conjugation of micro-zoospores.

It is interesting to note (1) that this process of conjugation is not a universal one with the micro-zoospores, but to a certain extent may be regarded as a chance union; (2) that the zoospores which conjugate are exactly similar as far as can be seen—that is to say, there is no sexual differentiation; and (3) that there seems to be a disinclination, if it may be so called, for two zoospores derived from the same original cell to conjugate. Dodel-Port, who made a very thorough study of this form, states that he never saw two zoospores from the same parent cell conjugate. The significance of this fact will be treated of hereafter.

A slightly higher stage in the differentiation of sexual reproduction is to be found in *Ectocarpus*.[8] This alga, like *Ulothrix*, produces in certain cells a single zoospore which germinates without conjugation. Other cells, however, give rise to large numbers of zoospores, which structurally are all similar but are evidently different physiologically. They are small masses of protoplasm provided with two flagella, one of which is directed forward in swimming and one backward. Some of these gametes after liberation swim about for a comparatively short time only, then settle down, withdraw their flagella, and assume a somewhat pyriform outline (Fig. 5029, I, *f*). Others, however, continue to swim about for a much longer period, and apparently tend to collect together in small groups. If such a group (Fig. 5029, II) be carefully examined, it will be found to possess, as the centre of attraction, one of the gametes which have early relinquished their locomotive powers. The anterior flagellum of each of the motile gametes is directed toward the sessile individual, and after a time one becomes entangled with or adheres to the latter, and is gradually absorbed by it, the gamete to which it belongs being thus drawn closer and closer to the attracting gamete, until finally conjugation of the two occurs (Fig. 5029, III).

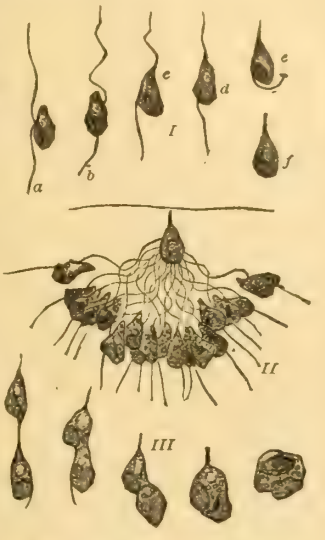

Fig. 5029.—Reproduction of Ectocarpus. (From Berthold.) I, Female gamete; *a* to *f*, changes undergone in settling down; II, group of male gametes collected round a female gamete; III, conjugation of gametes.

In this process a differentiation toward sexuality is to be seen. Of the originally similar gametes, those which quickly become sessile are to be considered female gametes, while the others, which retain for a longer period the power of locomotion, are, on the other hand, to be regarded as male gametes.

In *Cutleria*,[10] another marine alga of simple structure, a still more perfect differentiation of the male and female gametes occurs, the former being many times smaller than the latter; and from this the passage is easy to such a form as the fresh-water filamentous alga *Œdogonium*, in which the female gamete does not leave the enlarged cell whose contents have been transformed into it, but is there sought for, and, access having been obtained through an opening in the cell-wall, is fertilized by the smaller, motile, male gamete. The differentiation of sex, so far as the reproductive elements are concerned, really goes no further than this in plants, almost all complications met with in the higher and more specialized forms being either of a protective nature, or concerned with the phenomenon of alternation of generations which will be described later. Sufficient has been given, however, to indicate the very perfect series presented by plants, from the simplest non-sexual methods of reproduction to the very complicated sexual processes exhibited by the higher forms of plant life. Of course, it must be understood that the variations in the details of the process of reproduction are almost numberless, and although there are many offsets from the main line of progress which has been indicated above, still in all the same fundamental principles are concerned.

In the animal kingdom a somewhat similar passage from the non-sexual to the sexual process can be traced, but perhaps in not quite so complete a manner as in the lower forms of plant life. In the unicellular protozoa, simple division is an almost universal mode of reproduction, occurring in the simplest forms, such as *Protamœba*, and in the most highly organized infusoria. In some forms of the flagellata it is the only method known. In other members of the same group, by a repetition of the fission processes from an original individual organism, a number of descendants are produced which ultimately separate and pursue an independent existence. Such processes form an easy transition to what occurs in some of the chlamydomonadina, a family of the flagellata, some of whom present not a little similarity to the lower plants in their modes of reproduction, and in the possession of chlorophyll.[7] A preliminary of the reproductive process in these forms is usually the encystment of the originally free-swimming chlamydomonad; the next step is the division of the contents. In *Polytoma* this usually results, by a repetition of the process of division, in the formation of four or eight similar parts. By the rupture of the wall of the cyst these young polytomas swim away and, usually a few hours after obtaining their freedom, conjugate with each other, or with similar organisms from other cysts. There is an entire absence of difference of size in the two gametes which take part in the conjugative act.

This is not the case, however, in the genus *Chlamydomonas.* In one at least of its species, the cyst contents break up, in some cases with two or four parts, in others with eight. When they are liberated conjugation takes place, and according to one observer, only between the smaller forms, microgonidia, which are formed by the division of the cyst contents into eight parts. If this be a fact, it forms a stage in the evolution of sexual reproduction corresponding very closely to that offered by *Ulothrix* among plants. Another author, however, asserts that the conjugation takes place between the larger gametes or macrogonidia and the microgonidia, which would indicate that the process had nearly reached the condition exhibited in *Cutleria.* There is not, however, so great an amount of difference in size of the gametes observable in *Chlamydomonas* as in *Cutleria.*

In this respect another chlamydomonad, *Phacotus lenticularis* (Fig. 5030, 1), is more advanced. The macrogonidia in this species are formed by division into two or four parts (Fig. 5030, 2), while in the formation of the microgonidia the number of the parts formed is sixty-four. Whether in this case the conjugation takes place between the microgonidia only or between micro- and macrogonidia only, or irregularly, seems to be uncertain.

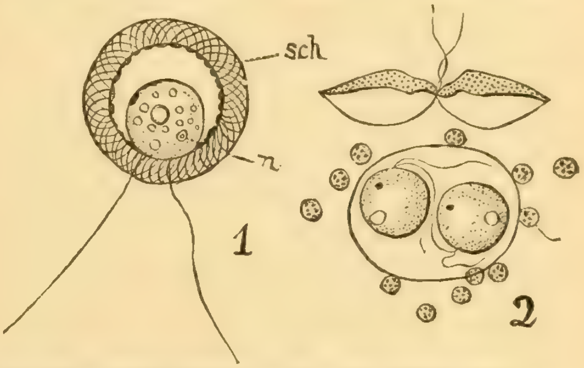

Fig. 5030.—Phacotus lenticularis. Ehrh. (From Bütschli in Bronn. 1. An individual viewed from flat surface; *n*, nucleus; *sch*, shell. 2, Microgonidia with two macrogonidia, the latter still retaining the capsule. Above is the ruptured shell of the mother-cell, from which they were formed.

The facts given above are by no means complete, but they represent fairly the information as to the development of sexual reproduction in animals which we possess. Taking them in connection with what has been described for the lower plants, it is evident that the distinction drawn between the non-sexual and the sexual processes of reproduction is merely an arbitrary one, the two processes merging into one another very gradually. Since the non-sexual method is the only one presented by the lowest forms of life, we must conclude that it is the more primitive process, and that the sexual method has been developed from it. How this development has been brought about can be imagined from what occurs in *Ulothrix.* It is evident that the greater the number of the spores produced, the greater will be the chance of some of them escaping the many causes of destruction to which they are exposed, and accordingly the tendency under natural selection will be toward plants and animals producing as large a number of spores as possible. But facts show that the smaller the spore (that is, relatively to its fellows) the less rapid and vigorous is the growth of the young plant or animal to which it gives rise, and, accordingly, the increase beyond a certain limit will become disadvantageous, and there will consequently be two opposing influences at work; on the one hand there will be an advantage gained by the production of a large number of offspring, and on the other hand the loss of vigor due to the smallness of the numerous spores will prove disadvantageous.

Conjugation, however, now steps in, and the difficulty arising from the minuteness of the numerous spores is obviated, but the number of offspring produced is diminished. Conjugation, however, affords many great advantages to compensate for this loss in numbers, which, moreover, need not be so very great, since the gametes may be reduced considerably below the minimum size of the corresponding spores which can develop. It permits, in the first place, cross-fertilization, *i.e.*, the union of gametes formed originally in distinct cells, or even in the cells of different parent plants, a process whose advantages will be discussed later. Secondly, as a result of the union of the two gametes, a renewal of the vigor of each, or a rejuvenescence, is produced, as is indicated by what has been observed in the Infusoria. Two individuals of a species of *Paramecium*, for instance, come together and fuse by their anterior extremities. In this state they remain for a considerable length of time, during which a rearrangement of the nuclear substance takes place, and finally the two individuals separate, to all appearance the same as before the conjugation, but in reality rejuvenated. Thirdly, as Weismann has pointed out, the sexual method "will tend to preserve the inherited individual variability of the unicellular individual or gamete, will increase it, and, by uniting it in ever new combinations, will allow of the possibility of the adaptation, under natural selection, of the species to new conditions of existence." In connection with this may be mentioned the interesting suggestion of Hatschek as to the part played by sexual reproduction in the elimination of disease. By the non-sexual method any organic disease will naturally be transmitted from generation to generation unimpaired; but sexual reproduction, by uniting diseased gametes with more vigorous, healthy ones, will tend to reduce the extent of the trouble, and will finally eradicate it.

Alternation of Generations.—The complete differentiation of the sexual mode of reproduction does not necessarily result in the suppression of the non-sexual method, but in most plants and in many animals both methods obtain.

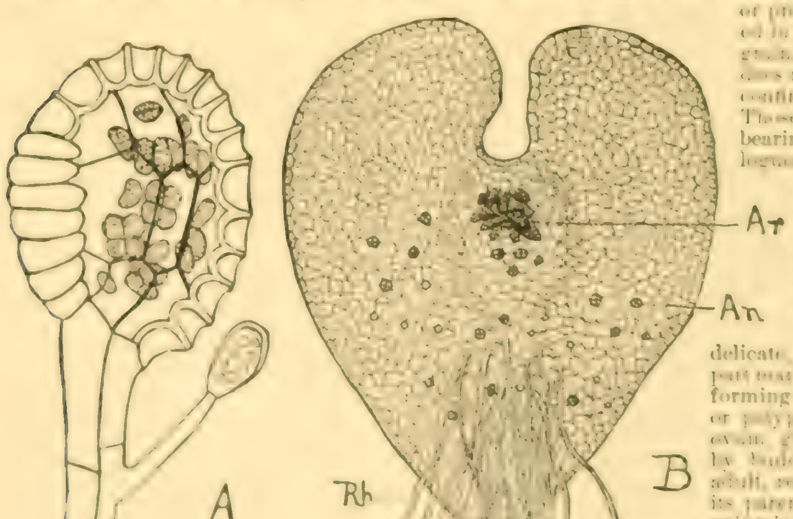

FIG. 3941.—A, Sporangium of Fern; B, prothallium of fern. Ar, archegonia; An, antheridium; Rh, rhizoids. (After Strasburger.)

A good example of this is afforded by the ferns. In the common Bracken (*Pteris aquilina*), for instance, at a certain time of the year there can be found on the under surfaces of the leaflets, close to the margin, small brown, stalked bodies arranged in confluent groups and protected by the reflexion of the edges of the leaflets. These bodies, sporangia (Fig. 3941, A), which, collectively, are known to gardeners as the "fruit," contain spores, and, when mature, burst, allowing the spores to fall to the ground. Should the conditions prove favorable, these spores germinate and give rise, not to another fern, but to a flat, heart-shaped, multicellular structure, technically known as a prothallium (Fig. 3941, B). Upon the under surface of this organs of reproduction, archegonia (Ar) and antheridia (An), develop, and from the fertilized germ-cells of the archegonia ferns develop. In this process we have a typical example of the phenomenon known as alternation of generations.

In these plants and in all "above them in the scale of organization, there is a regular alternation of generations of such a kind, that twice in the life history the plant is represented by a single cell, a spore, which in the one case has been produced asexually, and in the other sexually. The asexually produced spore gives rise to the sexual generation, the sexual generation produces the sexually produced spore, the sexually produced spore gives rise to the asexual generation, which again produces spores asexually" (Vines).

In higher plants the alternation becomes somewhat obscured by the development of sexuality in the non-sexual spores, and by the reduction of the sexual generation or prothallium. Thus, in Selaginellas the non-sexual spores are of two kinds, small microspores which give rise only to male prothallia, and larger macrospores from which female prothallia are developed. The prothallia in these cases are very much reduced in size, so much so that they hardly protrude outside the ruptured spore-walls, and in the gymnosperms and flowering plants the reduction reaches a still greater extent. The homologues of all the parts concerned in the alternation have, however, been made out in the pollen grains and ovules of the plants belonging to these groups, so that in them, as well as in the fern, the phenomenon of alternation of generation occurs. What we term a rose or an oak is the non-sexual generation, the sexual generation, or prothallium, being almost or quite aborted in the case of the microspore or pollen grain, and in the female spore, or ovule, does not form an independent plant, but is confined within the nucleus of the ovule. Those interested in tracing out in the cone-bearing and flowering plants the homologues of the various parts must be referred to the botanical text-books already mentioned.

In the animal kingdom the phenomenon plays by no means so important a part as among plants, but nevertheless it is occasionally to be seen. In its perfect form it is represented by the Hydroids, which are delicate, lowly organized forms, for the most part marine in their habitat.[*] They are colony-forming animals, *i.e.*, the original individual, or polyp, as it is called, produced from the ovum, gives rise to a second polyp-individual by budding. This eventually becomes an adult, retaining, however, its connection with its parent, and in its turn produces another polyp-individual, and so the process goes on until a colony, consisting usually of a considerable number of individuals, all in organic connection, is formed. Frequently all the individuals of one colony are not similar, but a physiological division of labor occurs among them, some being nutritive polyps, others becoming specialized for offence or defence, while others again become reproductive polyps.

These last give rise by budding, *i.e.*, non-sexually, to a number of bell-shaped structures known as medusæ, or popularly "jelly-fish," which in most cases are set free and swim about for a greater or less length of time. In these are developed the sexual reproductive organs, the ovaries and testes occurring in different individuals, and as the result of the fertilization of the ovum another polyp is produced and another colony started. Here we have true alternation of generations, the medusæ being the sexual generation produced non-sexually by the reproductive polyps.

In few cases, however, is the phenomenon so well exemplified among animals as in these forms. More usually when it occurs it consists of a succession of a number of non-sexual generations, the appearance of the sexual individuals being determined by the occurrence of unfavorable conditions, such as the approach of cold weather and the consequent loss of nutrition (see section on Parthenogenesis).

Heterogony.—In certain animals a phenomenon nearly related to alternation of generations, but in reality distinct from it, occurs. It has been termed heterogony by R. Leuckart, and consists of the occurrence, in the cycle of development, of individuals differing in structure from the parent forms and existing under special conditions of nutrition. A characteristic instance of this phenomenon is to be seen in certain parasitic nematode worms, as, for instance, in the *Ascaris nigrovenosa*, which occurs in one of its stages in the lungs of the frog. In this stage the parasites are usually regarded as females, but also possess spermatozoa, which are developed in special genital tubes earlier than the ova. Fertilization takes place within the body of the parent, and the young undergo development there, the reproduction being viviparous. The individuals of this generation make their way to the intestine of the frog, and are passed to the exterior with the fæces, and in moist earth or in water quickly assume their adult form, which differs from that of the parents and is known as the *Rhabditis* form. In this stage the animals are bisexual, and the fertilized females give rise to from two to four embryos, which become free in the body cavity of the mother and feed upon her organs, which degenerate into a granular detritus. When mature these forms make their way into the lungs of the frog, and the cycle of development is completed.

In another form, *Leptodera appendiculata*,[13] which is parasitic on the red slug (*Arion empiricorum*), several Rhabditis generations may succeed each other, otherwise the process is essentially the same as in *Ascaris*.

In some Lepidoptera and Spiders a phenomenon occurs, termed "seasonal dimorphism," which is essentially a heterogony of a lesser degree than that just described. In certain Malayan Papilios,[14] two or more different forms of females, each differing very decidedly in structure and coloration from the others, occur, as in *P. Paumon* (Wallace). Our North American *P. Glaucus* is a dimorphic female of *P. Turnus*.

Parthenogenesis.—In ovum-producing animals and plants it is the rule that fusion with the spermatozoon must occur before the ovum can develop to the adult form. Exceptions to this rule occur, however, especially among animals, an ovum being produced which can develop without fertilization. This phenomenon is known as Parthenogenesis. One of the most familiar instances of this is shown by the common Hive Bee. The ova deposited by the Queen Bee, as is well known, develop into queens or females, workers or sterile females, and drones or males. Dzierzon [2] found that when the queen was prevented from taking her nuptial flight the unfertilized ova which she deposited developed, but gave rise to drones without exception. Von Siebold also showed that in ova taken from thirty worker cells spermatozoa were always present, whereas in not one out of twenty-seven ova from drone cells could they be observed.

Parthenogenesis has been observed in many other insect forms, as, for instance, among the Lepidoptera [7] in *Sphinx Ligustri, Telea Polyphemus, Liparis dispar*, and *Bombyx Mori;* among the Coleoptera in *Gasterophysa raphani;* and among the Hemiptera in *Phylloxera vastatrix.*

In the last-named form the process is rather interesting, inasmuch as the occurrence of parthogenesis gives rise to a process resembling alternation of generations. Upon the roots of grape-vines infected with *Phylloxera* are to be found numerous galls produced by the insects. These root-inhabiting forms are wingless and deposit ova during the early summer, which develop parthenogenetically into wingless females similar to their parents. Several generations of such parthenogenetic forms are produced, but toward the end of the summer some of these females develop wings, ascend from the roots and fly about, thus disseminating the disease. These winged females produce from three to five parthenogenetic eggs of two sizes, the larger of which give rise to females, the smaller to males, destitute of any digestive apparatus, and fitted only for procreation. From a union of these males and females a fertilized egg results, which is deposited either under the bark of the stem of the vine, or in some cases upon the roots, the female having descended below the ground before depositing the egg. From the "winter egg" wingless parthenogenetic root-inhabiting females are produced in the following spring, and the cycle is complete.

Among plants parthenogenesis is a much rarer occurrence, and has been observed only in a few cases, as, for instance, in *Saprolegnia*, a fungoid growth which frequently makes its appearance on dead flies and other insects thrown into water, and even upon fish, etc., living in aquaria.

Parthenogenesis is to be considered a modification of the sexual method of reproduction. The parthenogenetic aphides and phylloxera are provided with a reproductive gland similar to that of the females of the sexual generation, and are in reality dimorphic females without the apparatus for copulation and fertilization which the sexual forms possess. The cells of their reproductive glands are similar to those of the ovaries of the sexual forms, and this fact has been recognized by applying to them the term *pseudova*, the ovaries being likewise denominated *pseudovaries.* Accordingly, it is more correct to regard parthenogenesis as a special form of sexual reproduction than to consider it a non-sexual process, and the parthenogenetic ova non-sexual spores.

It is in this respect that the reproduction of phylloxera differs from alternation of generations, which is an alternation of a strictly sexual with a strictly non-sexual generation. It stands rather as an example of heterogony.

Pædogenesis.—A peculiar variety of parthenogenesis has been observed in certain animal forms, and to it the name of pædogenesis has been applied by von Baer; it consists in the reproduction, parthenogenetically, of embryonic germ-cells. A very simple form of the process has been described by Metschnikoff, in a Medusa *Cunina*. Among the reproductive cells, which in this form are derived from the ectoderm, are found granular amœboid "neutral cells" much smaller than the motionless ova, which are in reality embryonic reproductive cells. They make their way through the supporting layer which separates the two germ-layers in the cœlenterata and passing into the endoderm soon begin to segment in a manner similar to ordinary fertilized ova. The result of this development is the formation of an embryo, and finally of a medusa somewhat different from the parent form. Metschnikoff has termed this sporogony, but it is closely related to the other phenomena usually grouped under the head of pædogenesis, and is essentially a very simple form of that process. Among the parasitic Trematodes which undergo a complicated metamorphosis pædogenesis occurs.[12] In the embryo which hatches from the fertilized ovum, so-called germ-cells, lying in the body-cavity, occur, in all probability corresponding to embryonic ova, which developing, give rise either to embryos similar to those which produced them, or to forms termed *cercariæ*, which are immature or larval stages of a form similar to the original adult parent. A full account of the changes undergone by these forms may be found in text-books on the subject.[12]

A better known instance is, however, afforded by the larvæ of certain dipterous insects (*Miastor, Oligarces*).[15] At that region of the body-wall where later the ovaries form, aggregations of cells take place, one of which enlarges and becomes what is termed a pseudovum, and from this a larva similar to the parent develops. From seven to ten of these larvæ are thus produced, and on the death of the parent they are set free and produce in a similar manner other progeny, a succession of parthenogenetic generations occurring during the summer, the last of which passes into the pupa stage and emerges in the following spring as a two-winged fly.

This process, like that of parthenogenesis, has been regarded as belonging to the category of non-sexual reproductive processes, but inasmuch as it is simply an accelerated parthenogenesis, embryonic reproductive cells being concerned in the process instead of adult ones, the remarks made while discussing the relations of parthenogenesis to gamogenesis apply equally well here.

Hermaphroditism.—We have seen that in the more primitive modes of sexual reproduction there is apparently no sexual differentiation of the two gametes which take part in the process, so that one may be termed the male and the other the female gamete, but both are similar to the zoospores which, as in *Ulothrix*, have the power of developing without conjugation. Since the sexual mode of reproduction is so universal among all but the lowest plants and animals, it might be thought that perhaps those gametes which have the power of developing without previous conjugation, were really comparable with sexual female gametes plus the male gametes which conjugate with them. In other words, the unspecialized gametes capable of developing without conjugation might be considered to be hermaphrodite gametes, containing within themselves both a male and a female part.

This theory, indeed, has been advanced by Minot and Balfour, and has been upheld by them as explaining certain phenomena connected with the maturation of the ovum, such as the extrusion of the polar globules (see articles on Impregnation and Sex). Leaving aside, however, the question as to the hermaphroditism of the unspecialized gametes and of, in fact, all cells, we have here to consider the facts with regard to hermaphroditism in the more complex multicellular individuals.

By hermaphroditism we mean the occurrence in one and the same individual of both male and female reproductive elements. It would seem probable that, in the first inception of the sexual reproductive process, both of the gametes might have been produced by the same individual, but it is also probable that such a condition would soon pass away, and that the advantages which are derived from cross-fertilization would tend to bring about a more complete separation of the sexual elements, the result being the establishment of bisexuality.

Among animals bisexuality is the rule, and in most cases where hermaphroditism occurs it can be shown to be due to some peculiar condition of existence which renders the chances for cross-fertilization few. Under such circumstances it will be advantageous, for the preservation of the species, that each individual should produce both ova and spermatozoa, since then there would be a greater chance of a number of ova being fertilized than if half the individuals produced ova only and the other half spermatozoa. The occurrence of hermaphroditism in the large majority of the higher plants is probably to be ascribed to the advantage thus gained, the danger resulting from self-fertilization being, however, carefully guarded against in most cases.

There is, however, another factor tending to counterbalance, and in most animals to more than counterbalance, this advantage presented by hermaphroditism, namely, the greater perfection of the elements and the higher potentiality for development probably produced by the separation of the sexual organs, and by the limitation of the energies of each individual to the production of a single kind of reproductive element.

In the higher plants, as already stated, hermaphroditism is the rule, though, as in the case of the members of the willow family, bisexuality occasionally occurs. In the ferns, too, examples of the latter condition are frequently found, and in the pteridophytes, in numerous cases, the prothallia are bisexual.

In animals, on the other hand, bisexuality is of much more frequent occurrence. The lowest forms of the metazoa or multicellular animals, the sponges, are hermaphrodites, but the cœlenterates are usually bisexual, the group of the ctenophores, however, being hermaphrodite, agreeing in this respect with their near allies, the turbellarian worms, to which again are closely related the hermaphrodite parasitic trematodes and cestodes. Among the turbellarians, however, bisexual forms (*Microstomum*) occur, and the nemerteans, which are also closely related to them, are as a rule, bisexual. Among the annelidan worms we find, as a rule, as also in the nematodes, bisexuality; those forms, however, which have assumed a terrestrial or fresh-water habitat, such as the earthworms and the leeches, are hermaphrodite. The same rule holds good with the mollusca, the marine forms being bisexual (with the exception of the pelagic pteropods and the opisthobranchs), while the fresh-water and terrestrial forms are principally hermaphrodite, although this condition is not quite so universal in the fresh-water as in the terrestrial forms, since in the fresh-water lamellibranchs it does not occur. The oyster forms an interesting exception to the usual bisexuality of the lamellibranch mollusca, and its hermaphroditism is usually considered to be correlated with its fixed mode of life; and to this same cause is assigned the hermaphroditism to be found in such forms as the tunicata and the polyzoa.

Among the crustacea some interesting cases occur, showing the relation of hermaphroditism to peculiar conditions of life; with very few exceptions the members of this great group, and also of that of the tracheata, are bisexual. The cirrhipedes, however, are mostly hermaphrodite, and we have in them some interesting phenomena.[illegible] Two peculiar genera, *Cryptophialus* and *Alcippe*, which live in the calcareous shells of other cirrhipedes and mollusca, are bisexual, the males being exceedingly aberrant in structure, being in *Alcippe* dwarfed and without digestive organs, mouth, or feet. The fact of the occurrence of these dimorphous males is an indication of the original bisexuality of the ancestors of the cirrhipedes. This indication is further strengthened by what is found in the genera *Ibla* and *Scalpellum*. These forms are hermaphrodite (with a single exception in each genus), but are nevertheless furnished with minute dwarfed males termed by Darwin "complemental males." Consequently, we have in this group three conditions: (1) bisexual forms with dwarfed males; (2) hermaphrodite forms with dwarf complemental males; and (3) hermaphrodite forms. The interpretation of the occurrence of these stages is simple. Upon the renunciation of the free life which their ancestors led, and which is still retained by their larvæ, it became advantageous for the cirrhipedes that they should have increased facilities for insuring the fertilization of the ova, and they became hermaphrodite. The occurrence of complemental males shows an intermediate stage in the development of pure hermaphroditism.

Among the vertebrates bisexuality occurs almost invariably, hermaphroditism being among them usually a monstrosity. In two genera of fish, *Serranus* and *Chrysophrys*, hermaphroditism occurs, and it has been occasionally observed in the carp, and in frogs and toads among amphibia in a more or less perfect degree.

With regard to the last case Pflüger[illegible] has suggested that among young frogs there are three forms, males, females, and hermaphrodites, the last changing either into males or females as development progresses. In this way, he thinks, is to be explained the somewhat frequent occurrence of ova among the cells of the testes of these animals. Although this is merely a suggestion and the process of change from an hermaphrodite to a unisexual condition has not actually been observed, yet there is no doubt but that in the embryonic stages of the reproductive organs the cells which give rise to the reproductive elements are quite unspecialized, and it is impossible to say, from a microscopical inspection, whether they will in the future develop into ova or spermatozoa. This is well shown in Fig. 5032, representing the embryonic testis and ovary of the earthworm, in which, owing to the presence of hermaphroditism and the separation of the male and female organs in different regions of the body, it is possible to ascertain which of the similar structures really represents the ovary and which the testis.

It is probable that the same undifferentiation of the mother-cells of the reproductive elements, and therefore of the reproductive organs, exists in the early stages of all forms, and it is only later that the sex of the individual is determined. Düsing[21] has lately published the results of a very detailed study of the causation of sex, and as a result of his investigations, concludes that equality in numbers must be the normal and proper proportion for the sexes, and any abnormal proportion tends to be corrected by the birth of a greater proportion of the sex whose numbers are below the normal. In other words, there is a tendency in all animals, when there is a lack of individuals of one sex, to produce more individuals of that sex. Düsing brings forward many facts to substantiate the statement, such, for example, as the well-known increase of the number of male births after a disastrous war. Since conception, late in life, is equivalent to a numerical lack of males, the statistics of primiparous births, in the cases of women of a somewhat advanced age, show a great excess of males. Absence of proper nutrition has great influence in determining the sex of the progeny, such a condition being equivalent to a lack of males, and therefore causing an increase of male births.

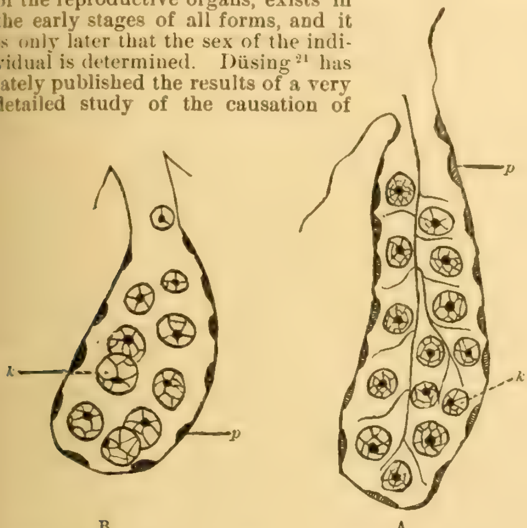

FIG. 5032.—A, Testis, and B, Ovary, of an Embryonic Lumbricus Turgidus. (After R. S. Bergh.) *p*, Peritoneum; *k*, reproductive cells.

Cross-fertilization.—There is no doubt that cross-fertilization, *i.e.*, the union of gametes from different individuals of the same species, the more remote their genetic relation the better, is of great advantage; and contrariwise, that self-fertilization and interbreeding, if carried to any extent, tend very markedly toward producing a deterioration and lessened fertility of the race. We are led to this conclusion partly by the experience of stock-breeders, and partly by the experiments on the subject which have been conducted by several careful investigators, especially by Charles Darwin.[22]

It may be of advantage to cite here some of the results obtained by Darwin. The first series of experiments recorded were upon a plant of *Ipomœa purpurea,* which is cultivated in gardens under the name of *Convolvulus major.* Ten flowers were fertilized by pollen from the same plant, and ten others by pollen from a distinct plant. The number of seeds produced by the crossed and self-fertilized flowers was very nearly the same. The seeds thus obtained were allowed to germinate in damp sand, and when germinated, a pair of seeds, one being crossed and the other self-fertilized, were planted on opposite sides of the same flower-pot, care being taken to place in contrast seeds which germinated at the same time. Three such contrasting pairs were placed in one pot and two in a second, while the remaining seeds, whether they had germinated or not, were placed in a third pot. Rods of the same thickness and material were supplied for each plant to cling to, and as soon as one of each pair had reached the top of the rod both were measured. In the third pot, the highest only on each side was measured. The results of growth in inches were as follows:

No. of Pot.	Seedlings from crossed plants.	Seedlings from self-fertilized plants.
	Inches.	Inches.
I	$87^4/_8$	69
	$87^4/_8$	66
	89	73
II	88	$68^3/_4$
	87	$60^4/_8$
III*	77	57
Total in inches	516	394

* Plants crowded; the tallest one measured on each side.

These plants were cultivated until they flowered, and the flowers on the crossed plants were crossed by pollen from other plants of the same generation, while the flowers on the plants from self-fertilized seeds were again self-fertilized. The same methods of germinating and growing were employed and the results noted; and so on through ten generations. The entire results are summed up by Darwin in the following table:

Number of the Generation.	Number of crossed plants.	Average height of crossed plants.	Number of self-fertilized plants	Average height of self-fertilized plants.	Ratio between average height of crossed and self fertilized plants.
First generation	6	86.00	6	65.66	as 100 to 76
Second generation	6	84.16	6	66.33	as 100 to 79
Third generation	6	77.41	6	52.83	as 100 to 68
Fourth generation	7	69.78	7	60.14	as 100 to 86
Fifth generation	6	82.54	6	62.33	as 100 to 75
Sixth generation	6	87.50	6	63.16	as 100 to 72
Seventh generation	9	83.94	9	68.25	as 100 to 81
Eighth generation	8	113.25	8	96.65	as 100 to 85
Ninth generation	14	81.39	14	64.07	as 100 to 79
Tenth generation	5	93.70	5	50.40	as 100 to 54
All the ten generations taken together.	73	85.84	73	66.02	as 100 to 77

It can be seen from this table that self-fertilization had a very decided effect upon the growth, the self-fertilized plants being on the average only a little more than three-fourths the size of the crossed plants. The plants of the fourth, seventh, and eighth generations, grown under unfavorable conditions, bring the average height of the self-fertilized plants a little higher, perhaps, than it should be, but, nevertheless, the difference is sufficiently striking.

It is not, however, only in height that the effect of inbreeding is shown. The general vigor of the crossed plants was evidently much greater than that of their self-fertilized companions. This was shown in various ways, as, for instance, by the greater hardiness of the crossed plants when subjected to low temperatures; by the greater strength of their stems, very evident in one case in the eighth generation, where the self-fertilized plant was higher than its crossed fellow; by their greater fertility; by the production of monstrous flowers on the self-fertilized plants of the ninth generation; and by the greater production of leaves by the crossed plants. This last difference was especially evident in the tenth generation, the weight of the leaves of the crossed plants being to that of the leaves of the self-fertilized plants as 100 to 44.

It is unnecessary to go into details with regard to other series of experiments conducted on plants belonging to a great many of the natural orders; those interested in the subject must be referred to Darwin's book, so full of suggestive facts relating to the whole subject of reproduction and heredity.

With regard to animals, facts similar to those just stated have likewise been noted, though no such comprehensive study has been given to the subject as has been done in plants. Darwin has given some facts on the subject which may be recounted here. He states that the white cattle of Chillingham Park, England, which have been inbred for a great many years, show lessened fertility. Wright paired a boar with daughter, granddaughter, etc., for several generations, with the result that finally the young were feeble, without inclination to suck, could not stand upright, and were mostly [illegible]. A relatively normal sow of the last generation would not pair with the original father, but did so willingly with a strange boar.

The disadvantageousness of self-fertilization being thus evident, it remains to be seen now just to what extent it is guarded against by plants and animals. We have already seen that hermaphroditism, and therefore the possibility of self-fertilization, is quite frequent among animals, and almost the rule among plants; nevertheless it is almost certain that in the immense majority of cases crossing of different individuals takes place. Thus in such hermaphrodite animals as the earthworm and snail, it is well known that pairing takes place, and the same would seem to be the case with many other similar forms. On the other hand, it is probable that in some degenerate parasitic forms, such as the trematodes and cestodes, self-fertilization is of by no means infrequent occurrence, crossing being wellnigh impossible in some cases, owing to the conditions of life. It would seem, too, that in certain cœlenterate forms self-fertilization is normal (ctenophores). But these last-named cases are exceptional, and one is justified in stating that cross-fertilization is the rule in the animal kingdom.

As regards plants, the researches of Kölreuter, Sprengel, Darwin, and Hermann Müller in particular have demonstrated that in flowering plants self-fertilization is certainly the exception, and many marvellous adaptations of form occur whose object is to insure crossing. Thus, in many cases, the stamens ripen before the pistils, or *vice versâ*; and in others the stamens become aborted in certain flowers, and the pistils in others; while in others, again, as the primrose, what is termed dichogamy occurs, consisting of the occurrence of stamens and pistils of different sizes in different plants of the same species, and so arranged that the long stamens are associated with the short pistils and *vice versâ*, fertilization occurring perfectly only between stamens and pistils of the same relative size. For a more detailed account of these and other wonderful arrangements, the reader must be referred to the special works upon the subject.

The conclusion which follows from the observed facts in cross-fertilization is that it is advantageous to the species, and that continued self-fertilization, on the other hand, is injurious. Instances can, however, be advanced which seem to indicate that self-fertilization does not in all cases necessarily prove disadvantageous. It seems that the value of cross-fertilization depends in reality on differences in the uniting gametes, which are the result of growth and development under different conditions. As the result of his observations, Darwin arrived at the following conclusions: "Firstly, that the advantages of cross-fertilization do not follow from some mysterious virtue in the mere union of two distinct individuals, but from such individuals having been subjected during previous generations to different conditions, or to their having varied in a manner commonly called spontaneous, so that in either case their sexual elements have been in some degree differentiated. And, secondly, that the injury from self-fertilization follows from the want of such differentiation in the sexual elements."

On this principle consanguineous marriages will prove disadvantageous only when the contracting parties have been brought up under the same or closely similar intellectual and physical conditions; and, on the other hand, cross-fertilization will lose its virtue to a very great extent in similar cases. These facts have been recognized by some breeders, who, when inbreeding is necessary for the preparation of some special variety, are accustomed to keep the individuals to be crossed on distant and diversely situated farms, by which arrangement the crossing, though between consanguineous animals, has nevertheless the advantages of a cross between forms possessing no close relationship.

As to the actual nature of the cause of the difference in the result produced by the union of similar and dissimilar gametes, we are at present in ignorance. Some have suggested a difference in chemical composition of the two gametes, and the inauguration by their union of a new series of chemical changes whereby added vigor is imparted to the progeny; but such a theory, however, needs substantiation. The same idea in a more general form might be expressed by saying that the benefit derived from cross-fertilization was due to the difference in the education of the gametes. Just as with mankind, a continuance of the same conditions tends to narrow or degrade the intellectual and moral natures, while the influence of new conditions of life, with the accompanying new ideas and new possibilities, is to educate and enlarge these natures, bestowing fresh vigor upon them; so new conditions may be considered to act upon the physique of the sexual elements. The mingling of gametes educated along different lines offers new possibilities and new vigor to the resulting individual; while a union of elements both educated to the same point, and along the same lines, cannot confer any advantages which the parent gametes did not possess, and if continued would naturally tend to a deterioration of the race.

There is a limit, however, to the degree to which the differentiation may be carried in order that good results may be obtained. Injurious results will follow from attempts to breed between forms too widely distinct. The best results are probably obtainable from forms of the same variety living in widely diverse regions, or in some cases between varieties of the same species. Crossing between decidedly distinct species is, as a rule, much less satisfactory, as may be seen in the case of the horse and the ass, where the progeny are almost invariably sterile, while attempts at crossing between members of different genera are usually unsuccessful. The education of the gametes in these cases has been along too diverse lines to yield good results. To take a simile from our own experience, again: Just as a Hollander and an Englishman, owing to the similarities of their respective languages, might succeed in understanding each other in conversation, so two gametes from forms belonging to different varieties of the same species might be able to harmonize and be mutually acceptable; whereas gametes from members of different genera would be able to understand each other as little as would an Englishman and a Chinese.

One other point of theoretical interest must be alluded to. This is the disinclination which exists toward union between consanguineous forms. This is to be seen in the case of the sow already referred to, which Wright found to be adverse to pairing with a closely related boar, while she did so willingly with a strange animal. Darwin has observed the same fact with regard to plants. He found that a plant's own pollen has a greater fertilizing power than, or, as he terms it, is prepotent over, that from a distinct species; while with regard to different individuals or varieties of the same species the reverse is the case. An illustrative instance may be given in Darwin's own words: "The pollen of Mimulus luteus regularly falls on the stigma of its own flower, for the plant is highly fertile when insects are excluded. Now, several flowers in a remarkably constant whitish variety were fertilized without being castrated with pollen from a yellowish variety; and of the twenty-eight seedlings thus raised, every one bore yellowish flowers, so that the pollen of the yellow variety completely overwhelmed that of the mother plant."

The most interesting case of this kind, however, has been already alluded to, viz., the disinclination which, according to Dodel-Port, exists in the zoospores of Ulothrix to unite with others from the same cell. It would seem that what might be termed a polarity existed in these lowly organized structures, the polarities in those from different cells differing, and there being thus an attraction between these; while those from the same cell, having a similar polarity, are mutually repellant. Some physical cause, no doubt, lies at the bottom of the phenomenon, but whether it is some force which we already know, or a form of energy as yet undiscovered, remains to be seen. *J. Playfair McMurrich.*

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REPTILES, POISONOUS.—Under the head of Reptiles, Poisonous, in Vol. VI. of this HANDBOOK, care was taken to add to the article three notes, which read as follows:

NOTE 1.—"With regard to the very poisonous qualities of the *Heloderma* saliva, recent experiments by the writer would seem to indicate an extremely feeble toxic effect, at least so far as rabbits and fowls are concerned."

NOTE 2.—"It is to be regretted that a repetition of de Lacerda's experiments with the permanganate by the writer has not given the results claimed by the distinguished Brazilian."

NOTE 3.—"A series of experiments are now being tried to verify what appears to be decided antidotal effects of *Jaborandi* to *Crotalus* venom, the writer having succeeded in saving rabbits which had received fourfold lethal doses of the poison. It has no antidotal effect, however, upon fowls."

The writer is now prepared to demonstrate that good ground existed for the notes as appended to the article, as the following experiments will prove. The first experiments have a direct connection with Note 1.

Before giving notes of the experiments made at the National Museum, it may be well to describe the process by which Drs. Mitchell and Reichert obtained the saliva of the *Heloderma*, and our own method. The first consisted in "provoking the reptile to bite on a saucer edge, which it was not disposed to do. When once it had seized the saucer it was hard to pull it away, so powerful was the grip of the lizard's jaws. After a moment a thin, fluid-like saliva dripped in small quantities from the lower jaw; it was slightly tinted with blood, due to the violence of the bite, and it had a faint and not unpleasant aromatic odor. The secretion thus collected from the mouth was distinctly alkaline, in contrast to serpent venoms, which are all alike acid."

Our own method consisted in forcing the lizard to bite upon a piece of artist's gum, which being elastic and yielding, did no injury to the teeth and afforded a fair hold. So soon as the saliva appeared to be flowing it was carefully swabbed up with pledgets of absorbent cotton, which were washed out with glycerine, and in this way we had no difficulty in securing all of the fluid needed. It was preserved in glycerine in the same manner as our serpent venom was preserved.

The first experiment, November 8, 1887, was as follows:

November 8, 1887, 12.17 P.M.—Held left hind leg of rabbit to *Heloderma*, who grasped it with his teeth, and held on for three-fourths of a minute, biting fiercely.

1.30 P.M.—Rabbit a little lame, but enjoyed eating as much as before.

3 P.M.—No result so far.

November 9th.—Rabbit appears to be perfectly well, with the exception of a very slight lameness of the left hind leg, due to the lacerated wound made by the lizard's teeth.

12.30 P.M.—Held leg of another rabbit near mouth of a different *Heloderma* from the one used in the former experiment, and irritated the reptile until he took hold. In this case the rabbit's leg was seized several times and bitten to the bone, the reptile being unwilling to let go. There was a copious flow of saliva, which ran over the teeth wounds and was rubbed in by the experimenters, care having been taken to remove the hair from the rabbit's leg. In fact this was done in every case, as it was feared the thick fur might prevent the saliva from reaching the wounds.

3 P.M.—No result.

November 10th.—No result.

November 11th.—No result except slight lameness.

November 17th, 12.45 P.M.—Injected three minims of solution of *Heloderma* saliva in leg of hen (brown); respiration somewhat increased, but no other symptoms noticed.

2.30 P.M.—Fowl in about the same condition; respiration slightly increased and breathes with beak partly open.

November 18th.—Fowl appears to be entirely recovered.

November 20th.—Hen completely recovered.

In this case the increased respiration was probably due to the fact that the chicken, being a very noisy one, it became necessary to compress its throat during the experiment to avoid annoying other workers in the museum.

November 22d, 12.19 P.M.—Injected ten minims of solution of *Heloderma* saliva and ten minims of water into left breast of another hen. This chicken was very thin, but perfectly healthy, and had been used for two rattlesnake-venom experiments with ligature and recovered.

12.25 P.M.—Increase of respiration; wants to lie down; defecates; feathers ruffled.

12.30 P.M.—Panting heavily; peculiar outward and inward movement of anus; eyes closed and very drowsy.

November 28th.—Chicken entirely recovered, and has been well for several days.

12.35 P.M.—Injected twenty-five minims of solution of *Heloderma* saliva into left leg of another hen.

12.40 P.M.—Hen lying down; respiration quickened, and breathes with mouth open.

2.30 P.M.—Chicken still lying down and breathing fast.

November 29th, 11 A.M.—In same condition as yesterday; will not eat.

November 30th, 11 A.M.—Improving; eats a little.

December 1st, 11 A.M.—Appears to be all right; eats well.

December 2d, 11 A.M.—Chicken entirely recovered.

December 5th, 12.15 P.M.—Injected twenty-five minims of solution of *Heloderma* saliva into breast of chicken; same quantity into right leg; same quantity into left leg, making in all seventy-five minims. In a short time fowl had copious watery discharge per anum, with a peculiar oscillatory movement of that opening.

12.50 P.M.—Chicken lying down, with its feathers much ruffled.

December 6th.—Chicken found dead. This fowl had been used for previous experiments, and was very thin and weak, and it is by no means certain whether the copious diarrhœa, probably produced by the glycerine, did not cause its death.

December 5th.—Forced largest *Heloderma* to bite a chicken on the leg (from which feathers had been removed) several times. There was a copious flow of saliva and many lacerated wounds.

December 6th.—Chicken seems perfectly well; no swelling or local manifestations whatever.

December 7th.—Chicken perfectly recovered.

Fearing that possibly the glycerine solution of saliva (two drachms of saliva to six drachms of glycerine) was too weak, or had lost its strength through keeping, on December 8th, the following conclusive experiment was performed:

December 8th, 12.15 P.M.—Forced open the jaws of the largest and most savage *Heloderma* and collected upon a piece of absorbent cotton from ten to fifteen drops of fresh saliva. An incision was made in the breast of a chicken and the cotton placed in it and allowed to remain.

December 10th.—The chicken appears perfectly well; no sign of indisposition or local manifestations whatever; wound appears to be healing by first intention.

January 20, 1888.—Wound in breast has been healed for some time; the cotton remains where it was placed, and can be felt encysted under the skin and has produced no injury.

April 4th.—The chicken alive and healthy, with the cotton still in situ.

This experiment would seem to show that a large amount of the *Heloderma* saliva can be inserted into the tissues without producing any harm, and it is still a mystery to the writer how Drs. Mitchell and Reichert and himself obtained entirely different results. Both the "Gila monsters" used by us were good-sized, active specimens, full of vigor, secreting a considerable amount of saliva, and we can hardly suppose that the short captivity they had suffered could have so modified their saliva as to render it innocuous.

With regard to Note 2, the results of a few conclusive experiments are given to show that the statement was warranted by facts.

Permanganate of potassa was the first substance used in the course of experiments, and de Lacerda's directions were carefully followed, with the exception that chemically pure glycerine was used as a menstruum to preserve the venom, instead of distilled water. The writer is aware that de Lacerda claims that if glycerine is used to hold the venom in solution, the permanganate is rendered inert; but that is not the case, as in our experiments it has been found that a five per cent. solution of the salt, if added to the glycerine and venom solution, neutralizes its venomous effects. Moreover, if a ligature is placed around the leg of an animal, and a certain quantity of glycerine venom is injected below the ligature, followed by a solution of the permanganate, no venomous effect is produced by the venom. This effectually disproves de Lacerda's statement. It should be mentioned that in all the experiments tried with the various reputed antidotes, different quantities of these were always first injected into the animals on the day preceding the test with the venom, in order to ascertain if the remedy itself was capable of producing mischief or death.

In order to ascertain the amount of glycerine venom required to destroy a pigeon, the following experiment was made:

October 21, 1887, 11.45 A.M.—Injected pigeon in the lower part of left breast with three minims of glycerine venom solution.

11.48 A.M.—Pigeon commenced to tremble and had difficulty in opening the eyelids.

11.55 A.M.—All voluntary motion ceased.

12 M.—A good deal of tumefaction was noticed around the part injected.

12.05 P.M.—The pigeon has recovered partial muscular movement and the eyes appear brighter.

12.15 P.M.—The pigeon has again lost muscular power.

12.35 P.M.—The pigeon gave two slight flutters, a few gasps, and was dead. A *post mortem* was made before rigor mortis set in, and it was found that the whole of the left breast was ecchymosed and congested with dark blood, and the heart was filled with venous blood.

It was thus discovered that three minims of the venom solution was sufficient to destroy a large, healthy, blue rock pigeon in less than an hour, the strength of the solution being eight drachms of glycerine to one drachm of the *Crotalus* venom.

October 22d, 11.43 A.M.—Injected pigeon with five minims of venom solution in the left breast.

11.45 A.M.—Injected seventeen minims of one per cent. solution of potassa permanganate in left breast.

11.54 A.M.—Convulsive movements of the pigeon's head were noticed.

11.55 A.M.—Injected seventeen minims more of the permanganate solution, as the bird was getting very feeble. Opisthotonotic spasms took place.

12.15 P.M.—The pigeon died without a struggle.

In this experiment the permanganate solution was injected twice in the immediate vicinity of the venom injection. It should not be forgotten that the one per cent. solution of the permanganate is the one recommended by de Lacerda.

October 25th, 12.45 P.M.—Injected a large, healthy, English rabbit, in the left thigh, with five minims of the venom solution, followed at once, without withdrawing the hypodermic needle, with an injection of twenty-five minims of the one per cent. permanganate solution.

12.50 P.M.—Rabbit began to show the effects of the venom; respiration very much quickened; heart beats fast and is weak; animal indisposed to movement.

1 P.M.—Rabbit drank a little water, but was breathing short and fast.

1.10 P.M.—Part injected quite swollen and ecchymosed, but otherwise the animal seemed to be better.

1.40 P.M.—Rabbit was eating, and appeared to be doing very well.

3 P.M.—Rabbit seems perfectly well, with the exception of a stiffness of the leg injected.

October 26th, 12 M.—Rabbit appears perfectly well, with the exception of a slight lameness and some swelling of the injected limb.

October 27th.—Rabbit found dead in the cage. *Post mortem*: Heart contracted; lungs, liver, and kidneys congested; bladder full of urine; intestines full of fæces. In the vicinity of the point of injection was found a large abscess, and the surrounding tissue and whole limb was ecchymosed, and had sloughed deeply. The liver, lungs, and mesentery were studded with parasitic cyst worms still living. Decomposition was well advanced in the affected leg.

In the next experiment it was decided to use a smaller dose of the glycerine venom, the subject being a large, healthy English rabbit:

October 27th, 11.45 A.M.—Injected rabbit in left hind leg (thigh) with three minims of venom solution, to which was added ten minims of water. Without withdrawing the hypodermic needle this was followed at once with an injection of twenty-five minims of one per cent. permanganate solution.

11.50 A.M.—Respiration and heart's action much increased, with a curious backward movement of the animal.

11.55 A.M.—Complete loss of motion in leg, with considerable tumefaction of part injected. Animal averse to motion even when irritated.

12.30 P.M.—Animal moves more freely, and seems better, although there is much more swelling and discoloration in the vicinity of the point of injection.

3 P.M.—Animal appears to be doing very well.

October 28th, 12 M.—Great tumefaction of leg and thigh; œdema of anus. Punctured and let out a large amount of bloody serum. Animal has eaten, but is averse to movement.

3 P.M.—Animal very sick, unable to stand; all motion of hind legs lost; is very weak.

October 29th.—Rabbit was found dead in its box, excessive hæmorrhage having taken place from the wound. *Post-mortem:* Great infiltration of blood in leg and surrounding tissue; much decomposition and sloughing

It was now determined to try the effect of placing a ligature around the leg of a fowl before injecting the venom, with the following result:

November 2d, 12.40 P.M.—After a ligature had been placed around the upper part of the thigh of a large, healthy hen, an injection was given, two inches below the ligature, of three minims of venom solution, to which was added ten minims of water. Without withdrawing the hypodermic needle, twenty-five minims of one per cent. permanganate solution was injected.

12.50 P.M.—The ligature was removed.

1.15 P.M.—No effect.

1.25 P.M.—Hen draws up the leg injected and stands on the other.

November 3d.—Fowl apparently in fair condition, but there is much greenish discoloration of the leg and softening of the tissues contiguous to the joint where the venom was injected; abscess forming. Is quiet and stands upon both legs, but does not use the left leg.

November 4th.—Fowl in about the same condition as yesterday; greenish discoloration more marked, but not extending so far into the surrounding tissue. Part quite soft and feverish.

November 5th.—Fowl suffering no inconvenience from the injection; discoloration of the part subsiding; very little swelling.

November 7th.—Discoloration and swelling of part injected have entirely disappeared and the hen has entirely recovered from the effects of the venom.

It will be seen from this experiment that the permanganate had a decided antagonistic effect to the venom, doubtless because the ligature confined the latter to a limited area, and prevented it being carried into the general circulation.

With a view to still further determining the beneficial effect of the ligature, the following experiment was tried with a large dose of the venom and of the permanganate solution:

November 10th, 12.45 P.M.—Injected ten minims of venom solution into right leg of hen below ligature, followed at once by twenty-five minims of two per cent. permanganate solution. Ligature was allowed to remain on three minutes. The tissues near puncture were well kneaded. (This chicken was injected before with three minims of venom, and one per cent. permanganate solution, and had entirely recovered).

2.30 P.M.—Fowl inclined to stand still, otherwise no other symptoms noticed.

November 11th, 11 A.M.—Fowl not inclined to move around, but sits down; not much swelling or inflammation of the part injected, but a little darker in color; eats well.

2.30 P.M.—Fowl appears to be much better than she was this morning; eats and drinks as usual.

November 12th, 11 A.M.—Hen slightly lame in the leg injected; part swollen, with greenish discoloration; eats and drinks well.

2.30 P.M.—Fowl in same condition.

November 14th.—Fowl entirely recovered.

It was thought advisable to try the antidotal effect of a much stronger solution of the permanganate, giving a small dose of venom solution, and not using the ligature, the result being as follows:

November 21st, 12.18 P.M.—Injected three minims of venom solution into left leg of a large, healthy hen, followed at once by twenty-five minims of a five per cent. permanganate solution through same puncture without removing the hypodermic needle.

12.22 P.M.—Leg drawn up and trembling; respiration quickened, and chicken lying down; can hardly be made to stand up, and oscillates backward and forward; feathers ruffled.

3 P.M.—Chicken will not stand; loss of motion of leg injected.

November 22d, 11 A.M.—Fowl somewhat better, can use the leg injected a little, but still inclined to lie down. Much swelling and greenish discoloration of the leg.

November 23d.—Hen in about the same condition as yesterday. Will not stand up.

November 25th.—Hen found dead; probably died yesterday (Sunday); much swelling and sloughing of the leg injected.

This same experiment was repeated upon other fowls and upon rabbits, the result being death.

It should be remembered in this connection that de Lacerda claims that, in nearly every case in which he used a one per cent. solution of the permanganate, the animal recovered, and moreover, he claims that the antidotal effect is produced even if a considerable period of time has elapsed after the injection of the venom. In our experiments we have shown that even a five per cent. solution is of no value, and the reputed antidote was used immediately after the injection—in fact, so soon as the venom was injected the barrel of the hypodermic syringe was immediately unscrewed from the needle, which was allowed to remain imbedded in the tissues, the syringe was rapidly filled with the permanganate, and the injection was then made. Sometimes less than half a minute was consumed in the whole operation.

In regard to Note 3, while it is as yet impossible to state that *jaborandi* has a positive antidotal effect to *crotalus* venom, the experiments seem to support such a view, and the writer has proof in his possession that a valuable dog was saved in Florida by this drug.

Dr. Robert Fletcher, in his valuable paper entitled "A Study of Some Recent Experiments in Serpent Venom," in the *American Journal of the Medical Sciences*, new series, lxxxvi., 144, 1883, mentions a case reported by a French physician, of a person bitten by a viper, in which the very grave symptoms developed had been cured by the administration of jaborandi, which produced copious salivation and perspiration, the dangerous effects of the venom gradually disappearing.

This case was looked up and was found in the *Gazette Hebdomadaire de Médecine et Chirurgie*, Paris, xix., 835, 1882, the reporter being Dr. Josso. He states that the patient was bitten by a viper between the thumb and index-finger, and that, when called to see her, all the characteristic dangerous symptoms of poisoning from snake venom were present, notwithstanding that phenic acid had been freely used as a supposed antidote. Having seen an account of the use of jaborandi by the South Americans in snake bite, he determined to give it a trial, and four grammes (about sixty grains) of the leaves were infused in a glass of water and given at 2 P.M. of the 13th inst., and on the 14th the patient was well, with the exception of pain in the arm and some swelling, which lasted for three weeks after the accident. As already stated, copious salivation and perspiration were produced, but no mention is made of any action upon the kidneys. As no other cases had been reported, and the writer being aware that jaborandi was supposed to be contraindicated by the state of the kidneys, he determined to examine the subject thoroughly.

As some non-professional readers may care to know what jaborandi is, and what effect is produced by it, the following short summary is given:

Jaborandi is an extract made from the dry leaves of *Pilocarpus pennatifolius*, a South American plant, its properties being due to a volatile oil and two alkaloids, pilocarpine and jaborine. The preparations and doses are:

	Dose.
Extract jaborandi	[illegible]
Infusum jaborandi	[illegible]
Pilocarpine nitrate	[illegible]
Fluid extract, U. S. Ph.	[illegible]
Tincture jaborandi	[illegible]

"**Pilocarpine stimulates the peripheral terminations** of efferent nerves going to glands, and first stimulates and then paralyzes the efferent nerves going to structures composed of involuntary muscular fibre. In large doses it lessens but does not quite destroy the irritability of voluntary muscles and motive nerves" (Lauder Brunton). "It increases flow of saliva enormously, the secretion of sweat, and excites the secretion of tears, certainly in cats, mucus from nose and from bronchial mucous **membrane, of gastric juice, intestinal juice, and** urine from the kidneys. Upon the circulation: vessels become **dilated at first, pulse rapid, feeling of heat** over the body. Blood pressure falls a little at first with **quicker pulse, and rises with a slower pulse. Respiration** is increased, with dyspnœa. It is used as a cardiac **stimulant when digitalis fails.**"

Now, as will be seen from these statements, this South American plant really seems to possess all those **properties which might be supposed necessary to constitute** a true physiological antidote to serpent venom, and so far as our limited experiments go, there appears to be good warrant for such a belief, as in all of our experiments the so-called antidote was first tried on healthy animals without producing any ill effects. The first experiment was as follows:

November 28th, 12.20 A.M.—Injected five minims of **solution of rattlesnake venom into left hind leg** of strong, healthy rabbit, followed immediately by ten drops of fluid extract jaborandi in ten drops of water; and ten drops of jaborandi and half an ounce of water was forced into the animal's stomach with a syringe.

2.30 P.M.—Animal slightly lame in the injected leg, holds it up when walking; eats well.

November 29th, 11 A.M.—Animal still a little lame, slight swelling and tenderness of the injected leg, otherwise seems to be in good condition.

November 30th, 11 A.M.—Rabbit in about the same condition as yesterday, but improving.

December 1st, 11 A.M.—Animal still slightly lame; a hard **tumor formed at seat of injection.**

December 2d, 11 A.M.—Rabbit in same condition as yesterday; appetite **normal.**

December 5th.—Swelling entirely gone; animal perfectly well.

It was noticed in this case that the animal urinated freely and very frequently, and that the mouth and nostrils were very moist. Chickens and pigeons being peculiarly susceptible to venom, it was determined to try the effect of the jaborandi **on them:**

December 3d, 12.30 P.M.—Injected five minims of *crotalus* venom solution into leg of chicken, followed by ten minims of fluid extract jaborandi, in water, by the stomach.

1 P.M.—Chicken appears not so well, lying down. Gave ten minims more of jaborandi, in water, per stomach.

3 P.M.—Chicken standing up, and feathers drooping; does not seem very sick.

December 5th.—Chicken found dead; probably died during the night, as it was alive yesterday (Sunday) at 1 P.M.

In this case it may have been that not enough of the jaborandi was given to overcome the double lethal dose of the venom, and also that none was given hypodermically; however, the experiment shows that life was prolonged after a dose of venom which, if allowed to act without hindrance, would have destroyed life in about two hours. Another experiment was tried upon a fowl, a smaller dose of venom and a larger amount of jaborandi being given, but the chicken only lived two days. These two experiments would seem to show that in the case of fowls poisoned by serpent venom, jaborandi has **only the effect of prolonging life. To verify the former** experiment upon a rabbit, it was resolved to again try the antidotal effect of the drug with the following result:

December 5th, 12.05 P.M.—Injected ten minims of *crotalus* venom solution into right hind leg of large, healthy rabbit, followed by fifteen minims of fluid extract **of jaborandi**; also gave fifteen minims of jaborandi, in water, per stomach.

12.15 P.M.—Rabbit sluggish, and indisposed to move. Respiration hurried, and animal seems very sick.

12.30 P.M.—Gave fifteen minims more of jaborandi hy**podermically.**

December 6th.—Rabbit appears perfectly well and is eating. Copious discharge of serum from wounds made by hypodermic needle, and a good deal of **urination.**

December 8th.—Rabbit appears perfectly well, but has a healthy looking raw surface near point of injection on leg, which is healing.

December 10th.—Rabbit well excepting ulcer, which is healing nicely.

December **12th.—Animal perfectly well.**

One more experiment was tried upon another rabbit, in which a fourfold lethal dose of the venom was injected, viz., twenty minims of venom solution, followed by sixty minims of jaborandi at intervals, hypodermically, with sixty minims, in water, by the stomach, the animal recovering perfectly. From the foregoing experiments with the fluid extract of jaborandi, it will be seen that while this substance appears to have antidotal effects upon rabbits, in fowls it fails, as has already been stated; **but it is intended to pursue this line** of experimentation **still further, especially with the active princip**le known as *pilocarpine*. It may be mentioned that a medical man of Washington City is so convinced of the efficacy of the **jaborandi, that he has offered himself for the purp**ose of **an experiment with venom, and in** addition to this offer **the writer has received a communication from** a person in Ohio, also proposing to submit to the test. Until we **have experimented further, however, the scientific** devotion of these gentlemen will not be tried.

The writer would like to acknowledge the aid rendered him by his able assistant, Mr. E. S. Rheem, in the preparation of this and the previous article in Volume VI.

Henry Crécy Yarrow.

RIVIERA. There is probably no region of country in all the civilized world of to-day that seems by nature so specially adapted to the purposes of a winter health-resort as is the strip of coast which extends in a northeasterly **direction along the shore of the Mediterranean** between Nice and Genoa, and, although in less degree, the continuation of this strip in a southeasterly direction beyond Genoa, and as far as Spezzia. The Italian name of this coast strip, "la Riviera," indicates that it is by them regarded as in some sense the *coast* land *par excellence*, and the name of the great post road between Nice and Genoa, "il Cornice," the "Cornice," is in itself almost enough to show the extreme narrowness of the comparatively level space intervening between the main chain and foot-hills of the Maritime Alps and the waters of the Mediterranean Sea. Moreover, when we come to consider the great depth of the sea at but a short distance from the shore-line ("two thousand feet a few yards from the land at Nice," Bennet tells us), and the very considerable height of the mountain chain lying thus close to the shore, it is evident that the small areas of level or gently sloping country which, intervening between the shore-line and foot-hills, are hemmed in on either side by the buttressing cross-ridges that run down to the very water-line itself, and that divide the whole coast line into a series of shallow bays, are in themselves no more than a series of shelf-like or cornice-like interruptions in the steep slope from mountain crest to sea-bottom. The conformation of the whole country is little else than a long shelf, or rather a series of shelves, on the south side of a very high mountain-wall, which wall, up to the level of these shelves, is submerged in the waters of the sea. This peculiar conformation, while in a great degree characteristic of the entire Riviera from Nice to Spezzia, is especially characteristic of that portion of the western Riviera which lies to the east of the Tête du Chien, a promontory jutting into the sea immediately to the west of Monaco, and about eight or ten miles to the east of Nice. West of this point the main chain of the Maritime Alps recedes much farther from the shore, and a much larger share in the production of shelter from northerly winds devolves upon their foot-hills. Such is the case at Nice, although even there the backbone of the Alps lies but thirty miles distant from the shore: such is still more the case at Cannes, which lies about eighteen miles southwest of Nice, and where the higher mountains stand nearly forty miles back from the coast. Yet both these places share in great degree the climatic characteristics of the better-sheltered portion of the coast, and may properly be considered as belonging among the Riviera resorts.

The latitude of the Riviera plays but a small part in the production of its mild winter climate, while the chief factor in determining the climate of this region undoubtedly is its extraordinary protection against northerly winds. The warm water of the Mediterranean Sea helps to maintain the relatively high winter temperature, and the prevalence of clear skies, allowing the sun's rays to strike with full power upon the rocky southern slope of the sheltering mountain-wall, has also a powerful influence in the same direction, especially during the day hours. "It has been calculated," says Dr. Yeo, in his work on "Climate and Health-Resorts," "that the temperature of the Mediterranean off this coast is twenty degrees higher than that of the Atlantic at the same depth and in the same latitude; and that the temperature of the surface of the sea (off the coast of Cannes), has a mean excess of about 12° Fahr. over the minimum temperature of the air, and a mean excess of 9° over that of the sea on our own southern coast (Falmouth)."

The mountain-wall that shelters the western Riviera varies in height from about nine or ten thousand feet behind Nice, where the main chain lies some thirty miles from the coast, and where many ranges of foot-hills intervene, down to four thousand five hundred feet behind Albenga, Noli, etc., where the crest of the chief ridge itself approaches to within seven miles of the shore, and where there is no longer any space left for the intervention of secondary ridges or foot-hills.

The climate of the Riviera is a moderately dry one, mild rather than warm during the winter months, and especially characterized by the general prevalence of bright sunshiny weather, by great heat of the sun's rays, and, above all, by its relative immunity from cold winds.

The most typical example of the climate of the true Riviera is to be found at Mentone, and it is purposed in the present article to avoid any attempt at lengthy discussion of this type, such information as may be desired on this subject having been already presented in the article entitled Mentone. Brief mention of other less celebrated Riviera resorts, as well as of Cannes and Nice, is all that the reader will find in this general article, a long array of figures and detailed discussion of meteorology or topography being avoided, and in their stead but a few words being said regarding the alleged special peculiarities of these other Riviera stations, and respecting their differentiation from Mentone, the Riviera type.

CANNES.—The town of Cannes lies on the French coast, twenty-eight miles southwest of Mentone. It is the least sheltered from northerly winds of any of the resorts mentioned in this article, being especially exposed to that curse of the Riviera, the mistral. Close to the town the dust is very annoying, at least it was so when Dr. Sparks wrote his work on the Riviera some ten years ago. The town is abundantly supplied with good water, and its drainage (in 1879) was in fair condition. Living accommodations are many and good, although by reason of the popularity of Cannes among the English, not yet abundant. The cost of living is especially high. The surrounding country is very attractive, and being far more open than that about the true Riviera resorts, which in fact hardly have any surrounding country, affords exceptional facilities for riding and driving. There are also good boating facilities. In regard to the opportunities for driving, Dr. Sparks tells us that Cannes "has a decided superiority to Mentone, and still more to San Remo;" for "not only can one go farther to the east and west of the town without encountering steep hills, but there are many more carriage excursions to be made inland." The immediate neighborhood of Cannes is "not so well off for walks as drives," he says, by reason of the building operations involved in the constant growth of the town. At the close of January, 1878, there were no fewer than seven hundred and fifty English families at Cannes. The many social gatherings and entertainments are an objectionable feature of life at this place, so far as the invalid is concerned. The subject of the winds at Cannes is very carefully considered by Dr. Sparks, and he sums up his conclusions by saying that he thinks there is little doubt but that it is a very windy place, and that like Hyères, the wind to which it is especially exposed is the "mistral," or dry, and often cold, northwest wind. Of the little village of Le Cannet, two miles and a half north of Cannes, he tells us that it is well sheltered under the hills; that the natives say it "feels no wind," and that "it is easy to believe that they are right." Out of a goodly number of statistics regarding the temperature, rainfall, etc., given in Dr. Sparks's work, I select for quotation only those for average temperature and relative humidity, presented on the authority of Dr. Marcet, and covering the years 1874–77, those of mean maximum temperature for three years, and of mean minimum temperature for two years. They are as follows:

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Average temperature........	53.6	48.2	50.23	48.5	50.7	55.7
Mean maximum temperature.	66.06	54.3	55.76	54.26	57.23	61.8
Mean minimum temperature.	46.9	39.7	44.5	41.0	44.6	49.2
Relative humidity..........	70.64	69.99	60.99	71.6	70.73	74.16

At Cannes, as at Nice and at Hyères, olive-trees are abundant, and Dr. Sparks tells us (op. cit., p. 36) that this tree "appears to be unable to support a temperature below 21° or 22° Fahr." The olives at Cannes are smaller, he says, than they are east of Nice; while lemon-trees, which are abundant about Mentone and San Remo, at Cannes are scarcely ever seen. Orange-trees, on the other hand, are to be found at Cannes in abundance, but of these two varieties of the genus Citrus he tells us that, "roughly speaking, two to four degrees of frost, Fahrenheit, kill the lemon, whereas we only hear of orange-trees being killed by relatively severe frosts, such as occurred in 1709, 1788–89, and 1829." *

Respecting the special climatotherapy of Cannes, Dr. Sparks pronounces it to be "distinctly a bracing place;

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* A. J. C. Hare, in his book, "A Winter at Mentone," says that oranges bear seven degrees of frost, i.e., a temperature of 24° F.; while lemons bear only four or five degrees of frost, viz., a temperature of 27° or 26° F.

[illegible] In fact, sometimes," although, he adds, that [illegible] "suits many people better than Mentone or San Remo, especially as the spring advances and the days get warm;" and he thinks "invalids who have wintered in one of these places often benefit by a change to Cannes at the end of March or in the middle of April."

Nice.—Proceeding along the coast from Cannes, in an easterly, or rather northeasterly direction, the next health resort of the Riviera series met with is the city of Nice, the largest town of the coast between Toulon and Genoa, having a population of 53,880 on the occasion of the last census preceding the publication of Dr. Sparks's book, and a transient population of winter visitors, according to this author, of from 10,000 to 15,000 more. The town itself stands directly on the sea-shore, but is backed by a sloping area of country intervening between the foot-hills proper and the shore, which is some four miles wide from east to west, and a trifle deeper or longer from north to south (Sparks). "It is only in the immediate neighborhood of the town," says the author just quoted, "and for a short distance from the coast, along the edge of the bay, that there is any level ground; the remainder of the area consisting of low ridges and shallow valleys with a general direction from north to south." The highest of the foot-hills back of Nice is the Mont Chauve, with an elevation of 2,824 feet, and standing seven miles back from the coast. The elevation of the main chain of the Maritime Alps behind Nice, offset by its very considerable distance from the coast at this point, has been already mentioned. The foot-hills north of the Nice amphitheatre are, as pointed out by Dr. Sparks, too far distant and too much intersected by valleys to afford very good protection against winds coming from that direction; in fact, they appear to be much like the "multis interessit vallibus colles" described in the "Bellum Alexandrinum" as surrounding the town of Zela in Pontus; and as to the more distant mountains he says that "they can scarcely benefit Nice as much as is generally supposed, owing to the cold currents which descend from the snow-fields on their southern face." The writer recalls a view of distant snow-covered peaks, seen from the top of the Observatory Hill at Nice early in March, 1866, yet at the same time in Nice roses were blooming in the open air.

Like Cannes, Nice is one of the windiest of the Riviera resorts. "The mistral blows about nine times in the year, chiefly in February and March, and it is accompanied by clouds of dust whose density has been compared to that of a London fog; while at the same time the amount of moisture in the atmosphere is reduced to a minimum" (Sparks). The average number of days of complete calm during the nine autumn, winter, and spring months, as quoted by Sparks from Teysseire, is 18.6, while the average number of days of gentle wind is 200.8, and that of strong wind days is 69.4, out of which 29.4 occur during the three spring months.

Teysseire's figures for mean relative humidity (1869–76), for mean temperature, and for *absolute* (not average) maximum and minimum temperatures during the twenty-eight years 1849–76, are given below, and are all the meteorological data we shall attempt to quote out of the many provided by Dr. Sparks.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Mean temperature	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Absolute mean maximum temperature	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Absolute mean minimum temperature	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean relative humidity*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Hotels and pensions abound at Nice, and villas, many of them handsome and surrounded by large gardens, are not only numerous in the city itself, but are also thickly scattered all over the hill-sides behind the town.

For cases of pulmonary phthisis the climate of Nice is by no means so well adapted as is that of the Riviera proper, east of the Tête du Chien promontory, although for that particular class of phthisical cases known as the "torpid," in whom open-air life alone is the chief consideration, and who have no febrile reaction and no marked susceptibility to taking cold, Nice is a good place of winter resort, provided they are careful to live away from the sea and to select a residence either in the relatively sheltered northern portion of the town, or, better still, at the suburb of Cimiez ("the Civitas Cimeliensis of the Romans," A. J. C. Hare), lying two miles from the sea, or at some other sheltered spot among the hills. For the chronic bronchitis of elderly people, for delicate women, strumous children, and dyspeptics, and for nervous diseases—excluding those accompanied by symptoms of excitement and also excluding all neuralgic cases—the climate of Nice appears to be a good one. The objections to the climate in the case of cardiac disease, and, above all, pulmonary disease, are such that Dr. Sparks very wisely remarks that "no invalid should ever think of settling down at Nice for the first time without consulting one of the local medical men." The closing paragraph of his seventh chapter deserves quotation in full, and its lesson should be impressed upon the mind of every physician who thinks of recommending this celebrated resort, which is to-day rather a pleasure resort than a refuge for invalids.

"As to amusements," says Dr. Sparks, "what with theatres, operas, balls, soirées, etc., there is only too much even for healthy people. The society is extremely mixed, as Nice is more uniformly frequented by the nations of Europe and the world than any of the other southern health-resorts; but the larger number of winter visitors come not for health, but for pleasure, which, in other words, means gambling at Monte Carlo, or playing baccarat at the clubs on the Promenade des Anglais. Certainly some of the social aspects of life in that city might well be dispensed with, and to search for [illegible] in any sense of the word we must not go to Nice."

Mentone.—This celebrated, and very justly celebrated, health resort not only lies within the true Riviera district, but by reason of its exceptional shelter against cold winds, as well as for other reasons, may be regarded as the type of all Riviera resorts. It has been elsewhere fully described (see article Mentone, Vol. IV., pp. 780–785). The accompanying illustrations give a very good idea of the appearance of the town as viewed both from the east and west, and are properly introduced in the present article as typically representative of the scenery of the entire Riviera. Fig. 5033 is a view taken from a terraced olive orchard on the Cap St. Martin, the headland separating the bays of Mentone and Monaco. The other view, shown in Fig. 5034, is taken from the shoulder of the Monte Bellinda, which, running out as a buttress into the sea, constitutes the Punta della Murtola. Both wood-cuts are copied from Dean Alford's interesting book on the Riviera, a work that cannot be too highly commended to such of my readers as may desire to get a fair idea of the scenery of this most beautiful region without visiting it in person.

Bordighera.—The little town of Bordighera (population in 1876 about 2,500), lying at the extremity of a promontory about ten miles east of Mentone, is peculiar among Riviera resorts in possessing (by reason of this very situation upon a promontory) a more distinctively maritime climate than is to be found at any other point along this whole coast. Mr. Frederick Hamilton, quoted by Sparks, describes the situation of the town, and its consequent climatic peculiarities as follows: "All the other health-resorts," he says, "Cannes, Nice, Mentone, San Remo, and even Alassio, . . . are more or less at the bottom of bays. The situation of Bordighera is quite the reverse. It stands on a promontory which projects into the sea more than any other headland in Liguria. Hence it gets more sea air than any of the places already mentioned. The winds from north of east, round by south, to a little north of west, all necessarily blow from the sea. Live where you will in the neighborhood, even seven or eight hundred yards from the shore and on the hills, you will still find yourself under the influence of the sea air, just as you would along the beach in the other health-resorts. . . . The result in a medical point of view is, obviously, that the climate of Bordighera should be advised only to those who may expect benefit from sea air. Such patients will have the advantage there of breathing the sea air *inland* (*i.e.*) without the inconvenience of the high winds, and the noise of the waves, which they would suffer from in other localities." Dr. Sparks adds that obviously in the latter part of this quoted passage Mr. Hamilton was speaking rather of the "Bordighera of the future," than of the town as it existed at the time his (Dr. Sparks's) book was written: for at that time all that had been built of the suburb of New Bordighera (the only portion of the town suited to the residence of invalids), lay close down by the shore on the west side of the promontory, exception made only of a few scattered villas standing among the olive groves between the main road, close to the beach, and the old Roman road, the Via Aurelia, a road which, running close under the base of the foot-hills a quarter of a mile back from the sea, was then (1879, October) being "partly resuscitated and converted into a boulevard." These foot-hills, covered with olives and pines, attain an elevation, according to Dr. Sparks, of from four hundred to (at most) one thousand feet. The old and compactly built town of Bordighera, standing at the very tip end of the promontory, is decidedly picturesque, as are all these Riviera towns, but is not suited to the residence of invalids, and the east side of the promontory, though "occupied by a charming valley, rocky and sandy, full of palms and lemons, abundantly watered and prettily closed in by towering hills," does not seem to be popular as a place of residence, probably, according to the writer just quoted (Mr. Hamilton), "because the cemetery stands in the centre of it, which is a drawback in most people's eyes." So that the narrow strip of olive-covered, nearly level country to the west of the promontory is evidently destined to be the chosen site for the growth of the new town. This strip, although flat, is

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* The contrast between these humidity data and those of Dr. Vincent at Cannes is very striking, and the writer cannot help suspecting that Dr. Teysseire's table for Cannes, which was quoted by Dr. [illegible] [illegible] when compared with those of [illegible] [illegible] with those of Nice. For Dr. Sparks is [illegible] [illegible] [illegible] [illegible].

[illegible] of the foot-hills, a point of exceedingly great importance in the Riviera, where the [illegible] [illegible] [illegible] [illegible] different portions of one and the same town may be said to possess entirely different climates.

FIG. 5033.

FIG. 5034.—Mentone from the East.

well drained, having a soil which consists of a mixture of sand and clay resting upon a loose bed of shingle. The desirable portion of this narrow strip is that which lies within a distance of a mile from the cape, and which contains, according to Mr. Hamilton, "over two hundred acres of building land," while "the hills behind offer double the extent." New Bordighera, and in fact all this western strip of country, is to a good degree sheltered against easterly and northeasterly winds by the Cape of Bordighera itself.

On the north, Bordighera is "almost completely protected" against winds, and "the outlines of the Alpes Maritimes to the northwest and west break the force of winds from these quarters" (Sparks). Against the southwest wind—a warm and moist one—it is, of course, not sheltered at all, and this wind "sometimes blows with considerable force." The westerly winds at Bordighera are "generally light breezes accompanying fine weather," according to Mr. Hamilton. Dr. J. Burney Yeo says that at Bordighera "the mistral is a west wind, being turned completely in that direction by the mountains behind Monaco," but that "from being forced to blow over the sea it loses somewhat of its dry and cold character." As to the local sea breezes, "which are not strong winds," he says that Bordighera naturally feels them more than do the neighboring resorts.

The following table, condensed from one given by Dr. Sparks, and containing data for temperature based on Mr. Hamilton's observations, will suffice to show the mildness of the climate and its very great similarity in this respect to that of all the other Riviera resorts:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Mean temperature	64.5	56.4	50.8	49.6	49.1	52.5	57.1	63.6

The observations were taken at a height of more than sixty feet above the ground. Mr. Hamilton's maximum and minimum readings for the same period, and his data for rainfall may be found in Dr. Sparks's book. "Snow and hail are of extremely rare occurrence, and as at Mentone, the former melts almost immediately after it falls" (op. cit.).

When Dr. Sparks wrote his book, the only really good drive at Bordighera was along the shore road (the Cornice). But, as at other points along the coast, the resident who is able to drive over rough and steep roads, or to ride on a donkey, has a choice of excursions to many exceedingly picturesque places in the back country; while for invalids the walking facilities in the immediate neighborhood are exceptionally good. "Leaving their hotel or villa," says Sparks, "they at once find a shady and level retreat under the olives; or, if able to ascend the hills, they can do so without having to encounter any very steep ascents." The extensive palm groves of Bordighera are famous. "I have been told," says Dean Alford, in the beautifully illustrated chapter of his book devoted to this peculiar feature of the place, "that there are probably more palms at Bordighera alone than in the whole of the Holy Land."

In regard to the climatotherapy of Bordighera, Dr. J. Burney Yeo says: "It is especially suited to invalids who want sea air; to cases of scrofulous phthisis in its early stages and other cases of early phthisis without any tendency to hemorrhage; to cases of throat and bronchial catarrh; to cases of chronic gout; of convalescence from acute diseases, cases of anæmia, and many other conditions of constitutional feebleness. Its climate is too exciting for the very nervous and sensitive."

SAN REMO.—The town of San Remo lies seven and a half miles east of Bordighera, at the bottom of a small bay, closed in by the two promontories known as Capo Verde and Capo Nero. The town itself, closely and compactly built, like other Riviera towns, is triangular in shape, and extends up the slope of a steep hillside, somewhat like the city of Algiers in miniature. Its population in 1881 was [illegible]. Owing to the narrowness of its bay and its relation to the general trend of the coast line, there is no extensive view (excepting, of course, that straight out to sea) to be had at San Remo, a point urged against it by Dean Alford and quoted by Dr. Sparks and Dr. Yeo.* The scenery generally is less bold and picturesque than it is at many other points on the coast: "the higher hills recede somewhat from the coast, and the nearer ones are wooded to their summits and present nothing particularly striking in form or colouring" (Yeo). The winds to which San Remo is chiefly exposed are those blowing from the east and southeast, according to Sparks; while Weber * states the comparative frequency of the different winds during the five months, November to March, as follows: N.E. and E., 115; N.W. and N., 154; S.W. and W., 101; S.E. and S., 25.

The mistral appears to be felt at San Remo as much as, or even a little more than, at Mentone. The soil is largely clay, and less readily percolable by water than at Mentone and at Bordighera.

The water supply is good. In point of temperature the climate is almost an exact counterpart of that of the West Bay of Mentone. It is considered less stimulating than the latter. There are many hotels in the newer outlying districts of the town, both on the west and east sides of its older portion; many villas, too, have lately been built, San Remo having grown greatly in popularity as a health station during the past ten or fifteen years. Many of the winter residents are Germans—fully half of them in 1879, when Dr. Sparks wrote.

In the matter of drives and walks, what was said of Bordighera may be repeated as applicable to San Remo, but Dr. Sparks says that there is no good sea walk close to the town. The market is good. The cost of living is about the same as at Nice and Cannes. Many data of temperature, humidity, etc., may be found in Dr. Sparks's book and in Dr. Weber's account already cited. The rainfall and number of rainy days appear to be less than at other Riviera resorts. The afternoon heat after the middle of April is less than at Mentone.

ALASSIO.—The town of Alassio, twenty-eight miles east of San Remo, "is situated in a lovely bay, having a southern aspect, well protected between two headlands, . . . is probably not so warm as San Remo, as it is more open to the northeast winds, and, the northern hills not being so high, the north wind (Tramontana) reaches a portion of the district close to the shore" (Yeo, op. cit.). The water supply is abundant and good, according to Dr. Sparks. Alassio, as regards the beauty of its scenery and in the way of picturesqueness, is one of the most attractive points in the eastern portion of the Western Riviera, and of late years has acquired some reputation as a health resort. Of meteorological data there is as yet a dearth, and such as are given by Dr. Sparks are by him subjected to much critical comment as regards reliability and practical usefulness. I shall therefore spare the reader these quotations.

No other resorts along the Western Riviera call for special mention in this article, although several others exist. As regards the Eastern Riviera, a good, and perhaps the best, type of such resorts as exist along this part of the Ligurian coast has been already presented in the article describing Nervi (Vol. V. of the REFERENCE HANDBOOK, pp. 151 and 152).

GENERAL CLIMATOTHERAPY.—The climate of the Western Riviera has been properly classified by Dr. Hermann Weber among the "dry, warm coast climates"—a classification justified by such data for temperature and humidity as have been presented in the course of this general article and in the special article on Mentone. The Eastern Riviera is less dry, consequently less stimulating, and, as a whole, rather less warm.

As has been already stated in the general article on Health Resorts (Vol. III., pp. 529-530), the Riviera climate is suited to the treatment of cases of bronchial catarrh, chronic bronchitis, laryngeal catarrh, and pulmonary phthisis in its earlier stages, and when not accompanied by very marked febrile movement or by a special tendency to hæmoptysis. In cases of general progressing phthisis, with formation of cavities—a class of cases where least benefit is to be expected from any climatic treatment—even Dr. Weber, a strong advocate of "high-altitude" resorts, gives the preference to Mentone and like resorts, and pronounces against what may be called the "high-and-dry" sanatoria that are so much in vogue to-day. For diabetes, chronic renal disease, and chlorosis the entire Riviera is well suited, as it is to cases of anæmia and of "threatened phthisis" in strumous children. Such of the Western Riviera resorts as are most sunny and sheltered, and least "fashionable" as regards the matter of social entertainments are well suited to cases of rheumatism and gout. For the functional ailments characteristic of old age the Riviera is also a good place of resort; but persons having a tendency to apoplexy are by some writers loudly warned against taking up a residence in this region.

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* Dr. [illegible] says of San Remo that, "though beautiful and [illegible], it [illegible] and scenery which made Mentone so attractive."

Dr. Weber's statistics, showing the result of one hundred and twenty-four winters passed on the Riviera by 63 patients suffering from pulmonary phthisis certainly speak well for the climate. Of these patients 36 were in the first, 15 in the second, and 12 in the third stage of the disease. I give his results below in tabular form:

	Cases.	Improved.	Unimproved.	Worse.
First stage	36	22	3	11
Second stage	15	6	3	6
Third stage	12	2	5	5

As summed up by Dr. Weber himself these figures showed 47.6 per cent. of improved cases, 17.5 per cent. unchanged, and 34.9 per cent. of patients who grew worse.

He quotes also the statistics of the two Doctors Williams, based upon their observation of one hundred and fifty-two phthisical patients who had passed two hundred and twenty-nine winters in the Riviera. These observers found 62.5 per cent. of improved, 20.39 per cent. of unimproved, and only 17.10 per cent. of retrograde cases; and Dr. Weber very justly remarks that even better results could be obtained were patients only more prudent in regard to avoiding the special climatic risks peculiar to the Riviera (*e.g.*, the great contrast between sun and shade temperatures and between the temperature immediately before and immediately after sunset, and a foolish exposure to the sea-breeze such as is spoken of and warned against by Dr. Bennet—vide article "Mentone"), and were they only more careful in matters of diet, more disposed to keep away from the social gatherings of such places as Cannes and Nice, and more ready to consult the local physicians.

A very similar climate to that of the Genoese Riviera is to be found in Southern California; indeed, so far as climate *alone* is concerned, the Southern California resorts are probably superior to those of the Riviera. For patients, however, who are not imperatively called upon to select the very best possible climate for their disease, and particularly for those—and they are many—in whom a distraction of the mind, such as is effected by beautiful and picturesque scenery and by objects of historical interest, is an important element in cure, there can be no comparison between the much more varied and infinitely more picturesque scenery of the Riviera and that of California; nor between the historical interest of a country where the towns to-day look much as they did in the middle ages, where there are occasional remains dating from the classical period, (*e.g.*, the Via Aurelia, the Roman ruins at Turbia, Veilles, Carnolles, Cimiez, and Ventimiglia), and where, as in the celebrated bone caves of Mentone, not only implements belonging to, but actual skeletons of, prehistoric men have been discovered, and the historical interest of a country whose scanty remains are those merely of a remote Spanish colony not over three hundred years old.

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Huntington Richards.

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[1] Climate and Health Resorts, by Dr. J. B. Yeo.

[2] Klimatotherapie, in Ziemssen's Handbuch der Allegemeinen Therapie.

RUMINATION IN MAN. Synonyms: Merycism (from Gr. *μηρυκισμός*); Fr., Mérycisme; Ger., Merycismus, Wiederkauen; Lat., Ruminatio. Medical literature, especially that of recent years, contains numerous instances of rumination, or "chewing the cud," occurring in the human subject. At a period usually of from ten minutes to half an hour after the ingestion of food, though sometimes during the progress of the meal, the subject of this peculiar complaint suddenly feels the presence in the pharynx of a bolus of food, which has been regurgitated from the stomach without any conscious effort on his part. This regurgitation is usually unaccompanied by any subjective symptoms, either pain or nausea, though, if for any reason it do not occur, the patient commonly experiences a feeling of discomfort and weight in the stomach until the process of digestion is completed. In most cases the rejected bolus of food is neither bitter nor acid, unless the regurgitation has been delayed beyond the usual time, and the subjects of the malady not infrequently describe the process as a pleasant one, expressing their dissatisfaction at anything which may happen to prevent its recurrence at the usual time. M. Blanchard, who is himself a mérycole, as the human ruminator is called, testifies to the pleasurable sensations experienced in the act, and even confesses to having occasionally selected by preference certain articles of food which his previous experience had taught him would most promptly cause rumination, or which would have a specially agreeable taste when masticated a second time.

The condition is sometimes congenital, or at least the subject cannot remember the time when he did not ruminate, and there are many people doubtless who are mérycoles without knowing that they differ in this respect from their fellows. Blanchard learned that his rumination was abnormal only when he began to study physiology. It may even be hereditary, several cases being on record in which father and son were both ruminators. It occurs usually in persons who are large eaters, and in those who bolt their food without properly masticating it. Occasionally the habit is an acquired one, coming on without any apparent reason, or being referred to various and dissimilar causes. Brown-Séquard is said to have suffered for a time from merycism, brought on by some experiments made upon himself to determine the time required for the digestion of various alimentary substances. In conducting these experiments he enclosed the articles of food in a sponge to which a string was attached, and after a certain period of time he brought up the sponge by pulling on the string. After this had gone on for a while he found that the sponge was returned spontaneously, and then whatever was swallowed was returned in the same way. In another case, reported by Dehio, of Dorpat, the habit of ruminating was attributed to a violent and long-continued attack of whooping-cough, the paroxysms of which were always terminated by vomiting. Goldenhorn, of Odessa, relates a case occurring in a young man, which was associated with neurasthenic symptoms brought on by excessive sexual indulgence. Another case, reported by Boas, of Berlin, occurred in the person of a merchant who had travelled extensively, and had indulged for a long time in excesses of eating and drinking. Jürgensen, of Copenhagen, saw a case in a young girl, in whom rumination began without any apparent cause when she was ten years of age. Both the father and the grandfather of the patient were mérycoles. This case is exceptional by reason of the sex of the patient, most of the recorded instances having been in male subjects. In a few of the reported cases a distinct neuropathic family history was present, epilepsy in some of the immediate relatives being noted, but in other cases no such history was found. Among the exceptional and accidental causes of merycism may be mentioned oesophageal diverticulum. The act in such a case is, however, not properly merycism, but is simply a regurgitation of food which has become lodged in the diverticulum.

In the absence of any other explanation, merycism was formerly regarded as a pure neurosis; but recently Alt, Boas, and Jürgensen have published cases in which there was found an alteration in the amount of free hydrochloric acid present in the stomach during digestion. It is somewhat singular, however, that this change was not the same in the different cases, for in one case there was hyperacidity, in another the amount of free acid present was less than normal, and in two there was complete absence of this element of the gastric secretion. In some cases a moderate amount of dilatation of the stomach was noted, while in others no change of this sort could be detected.

Usually the merycole is healthy in every other respect, and the process is doubtless often beneficial, since, as in the ruminants, it provides for a remastication of food which has been hastily swallowed without having been properly chewed and mixed with the saliva. Dr. Hubbard, of [illegible], N. Y., reports a case in illustration of this. A previously healthy man consulted him in the hope of getting back his "lost cud." He stated that he had always been a ruminator, but that the habit had suddenly left him a short time before. He was a very large eater, and was accustomed to swallow his food without sufficient mastication, but had never suffered from dyspeptic symptoms, as the food was invariably regurgitated a short time after the termination of the meal, and was chewed leisurely. Since the cessation of the habit, however, he had been a martyr to indigestion.

An alarming suggestion has been made by Martel, to the effect that man is destined in time to become a ruminant animal. The habit of rumination, he says, quoting Blanchard, was acquired by certain animals at the time that the carnivora appeared upon the earth. Fearful of attack, the ruminants grazed rapidly, ready for flight at the first intimation of danger. Then, having reached a place of safety, their food was regurgitated and masticated thoroughly. A similar condition is obtaining in man, he asserts, in this age of hurry; and unless we learn to be more deliberate in our eating, and to masticate our food in the first instance more carefully, the necessities of digestion will compel a regurgitation and rechewing of the food, which has been so imperfectly prepared for the action upon it of the gastric and intestinal secretions; and in time this process, which is now exceptional in man, will become habitual.

In the present state of our knowledge concerning the nature and cause of merycism, it is difficult to discuss satisfactorily the subject of treatment. It is, of course, necessary to study the individual case with care, since the causes of acquired rumination are so varied. In a case of so-called congenital merycism, in which no cause can be found either in the mode of eating or in the state of the gastric secretions, it is probable that but little can be done in the way of ameliorating the condition. In such a case, indeed, the physician ought to proceed with some caution, since, were he successful in breaking off the habit, it might well be that more harm than good would result from his efforts, the patient, who was before a merycole suffering only from the comparatively slight annoyance of his habit, becoming merely a confirmed dyspeptic.

In the case of a voracious eater, a certain measure of self-restraint and greater care in the mastication of food may, by removing the occasion of rumination, abolish the habit. The character of the gastric secretion should be examined into, and if hyperacidity be found to exist it should be corrected by the administration of acids before eating, or of alkalies after the ingestion of food. Alt has reported a case of this nature in which a cure was obtained. The patient was a rapid eater and used to swallow his food very imperfectly masticated. There was a slight degree of dilatation of the stomach, some patency of the cardiac orifice, and examination showed an excess of free hydrochloric acid. The digestion of albumen was very rapid, while that of starchy matters was imperfect. It was only after these had been returned to the mouth and again chewed and mixed with saliva that they could be digested. The treatment consisted in lavage of the stomach, galvanism of the oesophagus, an albuminous diet, and the exhibition of large doses of alkalies. A complete cure was obtained in a fortnight. The use of the stomach-tube alone has in certain cases been found productive of benefit, although no cure by this means has been reported. Jürgensen relates an instance of this kind in which the smallest amount of food swallowed in the usual way was always rejected, while a much greater quantity introduced through a tube was retained without the slightest trouble. Boas believes that the mechanical effect of the sound upon the nerves of the stomach is of service, and thinks that the therapeutical value of this procedure in gastric affections is not sufficiently appreciated. In cases such as those reported by Jürgensen and Boas, in which there was a deficiency of acid, the administration of acids in connection with hygienic and dietetic measures would be indicated.

The following is not offered as a complete bibliography of the subject of merycism, but the reader will find in it references to some of the more important articles on the subject, most of which have been consulted in the preparation of this brief sketch of the disease.

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Thomas L. Stedman.

SKIN AND ITS APPENDAGES, THE ANATOMY OF THE.

The skin, or integumentum commune, of the body acts as a covering and a protection for the deeper portions, besides being an organ of excretion and absorption and the seat of the sense of touch. Embryologically, it is developed from those two primitive layers of the blastoderm, the ectoderm and the mesoderm, which are formed by the cellular division of the impregnated ovule. The epidermis, or most external layer of the skin, is formed from the ectoderm, while a superficial portion of the mesoderm furnishes the remaining constituent parts, the corium or cutis vera, and the subcutaneous or fatty tissue.

GENERAL CHARACTERISTICS.—When fully formed the skin can be regarded as a completely closed sac, which moulds itself so closely upon the portions of the body which lie immediately below it that it allows their shape and configuration to be more or less accurately distinguished. This, naturally and to a great extent, will depend upon the amount of intervening fatty tissue, which, when in excessive amount, entirely destroys that symmetry and roundness of form dependent upon its presence in moderate quantity.

The skin does not stop abruptly at all the natural openings of the body. It is continuous at these points with the mucous membrane which clothes the cavities. At the nares, on the labia majora and minora, and on the external surface of the anus, the same skin is present as on the rest of the body, and it goes gradually over into the mucous membrane. At the mouth, however, on the eyelids, and at the meatus urinarius, the transition is abrupt.

The integument is very variable in thickness. In general it varies between $\frac{1}{2}$ and 4 mm. ($\frac{1}{50}$ to $\frac{1}{6}$ inch), exclusive of the subcutaneous tissue. It is thinnest on the eyelids, and thickest on those portions which are subjected more especially to pressure, as on the palms and soles, or which serve as points of insertion for muscles, as on the upper lip, alæ nasi, etc.

Density and Elasticity.—It has been found that the skin possesses considerable solidity and very perfect elasticity. Sappey concluded from his experiments that a strip of skin 3 mm. long and 10 mm. broad was able to support a maximum weight of 12 kilos (26$\frac{1}{2}$ lbs.). The solidity was also in direct ratio to the thickness of the piece of skin used in the experiment. As mentioned, the elasticity is very perfect, but slight; a considerable amount of stretching may result from the application of a small weight, but complete rectification takes place after its removal. The skin is not of uniform texture; but consists of bundles of fibres arranged like a net, between which are spaces of various sizes which are rhombic in shape. In these spaces there is found a cementing substance, and it is due to it that the former are able to regain their natural shape after having been stretched. Rollet observed, that when this cementing substance had been destroyed the elasticity of the skin was lost; consequently, he concluded that the elastic property of the skin must be ascribed to its presence.

Cleavage.—The cleavage lines of the skin were discovered by Langer. He pierced the skin with small, round awls, and, after removal of the instruments, observed that the wound which was made was a linear one. He then made series of them in rows and close together, and from the uniformity in the direction of the long axes of a more or less greater number of the small wounds, he was able to conclude that the skin possessed complete linear cleavage over the greater part of the surface of the body. Not on all, however, for in some places, as on the forehead, on many points on the scalp, etc., the wound made was a triangular one, and he found that these occurred where two spaces met together which possess linear cleavage in opposite directions.

The explanation of the fact that the skin is, to a great extent, cleavable linearly, is to be found in the arrangement of the spaces between the bundles of fibres. These spaces are of various sizes and shapes, and in many places are so stretched longitudinally and so narrowed that the fibre-bundles run almost parallel to each other. The course of the cleavage lines of the skin can be well understood by consulting the accompanying figure.

Tension.—Except upon the scalp, the palms of the hands, and the soles of the feet, the skin is, more or less, in a state of tension. When a portion is excised, it will be seen that it diminishes in size to such an extent that it will no longer cover the surface which has been laid bare. This cannot be ascribed entirely to the retraction of the borders of the wound, but is also due to the diminution in size of the excised piece, which is then no longer subjected to its former tension. Where the skin possesses linear cleavage, the tension is in the direction of these lines, but where this condition does not exist, it occurs uniformly in every direction in the plane of the surface. The tension likewise depends upon the movements of the joints and muscles, the amount of fat deposited in the subcutaneous tissue, and also upon morbid conditions, such as œdema, or upon the existence of pregnancy. In this latter condition the degree of tension may be so great that a permanent change may result in the direction in which the bundles of fibres run.

Color.—The color of the skin differs according to the individual, the race, and the age, and it also varies upon different portions of the body. It cannot be ascribed in certain races to climatic influences alone, since in the same zones people of different color are found, as in Africa negroes, and in a corresponding portion of America the much lighter-colored Indians. The difference in color depends entirely upon the amount of pigment present in the epidermis, where, under the form of granules, it is found especially in the lowest layer of the epithelial cells forming it. This is easily demonstrable in the skin of the negro two or three days after death, and before decomposition has set in. If the skin is, under such conditions, sharply rubbed, the epidermis is detached and rolls up under the finger, and the corium or true skin being exposed is seen to be of a dull white color.

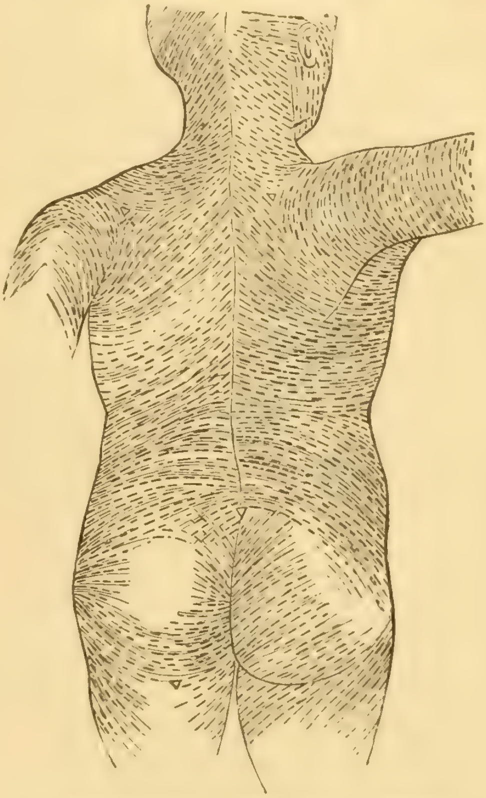

FIG. 5035.—Cleavage Lines of the Skin. (Langer.)

In the white race the color changes, within certain limits, in the various seasons of the year. When exposed to the heat and the sun in summer, there is an increase in pigment deposit and it appears darker, but this disappears and the whiter color returns in winter.

Under certain physiological conditions, such as pregnancy, there is likewise an increase in the amount of pigment in particular portions of the skin—the areola around the nipple, the linea alba, etc.—and this may in some instances be to an exaggerated extent. A large portion of this increase often disappears after the birth of the child, but a considerable amount usually remains. In the male the scrotum and penis, and in the female the vulva, are of a darker color than the rest of the skin. The pink or red color seen on certain portions of the body, as the cheeks, or induced by certain temporary causes, as those which produce flushing, is due to the blood in the vessels of the cutis. These latter becoming filled with blood its color is conveyed to the eye through the epidermic covering. When venous congestion is present the color to more or less of a brown tinge, as can be seen when certain portions of the skin with natural sluggish circulation, the nose, etc., have been subjected to cold. In old age the skin acquires a more or less yellow color, which is due to the atrophic changes that take place in it, and also to the lessened amount of blood supplied to it.

The Folds and the Furrows of the Skin.—There are many furrows which are seen on the skin. Some of them are long and deep, others are short and shallow. The former are present to a great extent from birth, and are seen running in a transverse direction across the extensor and flexor surfaces of joints. The latter are represented by the wrinkles on the face which develop with age. These latter are due partly to the diminished elasticity and turgescence of the skin, but they are induced more often by muscular contraction and stretching of the cutis.

The furrows around the joints are produced by the movements of flexion and extension. They are not able to overcome directly the tension of the bundles of fibres which, in this situation, run transversely or obliquely across the joints, and, in consequence, the fibre bundles are not stretched by the ordinary movements, but the interstitial spaces between them are. On one side of the joint their tension is in the direction of their breadth, while on the opposite side of the joint the fibre bundles are brought closer together. In this way the constant furrows around the joints are caused. Those which are due to muscular action, as the wrinkles on the forehead, etc., are produced in the same manner, the constant repetition of the movements finally effecting a permanent change in the arrangement of the fibre bundles and of the spaces between them.

The folds seen in very emaciated persons are likewise caused by the diminution in the size of the interstitial spaces. This is brought about by the loss of fat and the consequent change in the arrangement of the fibrous structure of the skin. Coarser furrows are also seen on the palms of the hands and on the soles of the feet, and in these places the skin is not movable. These furrows are always permanent, being caused by the firm union of the skin to the tissues below by means of short bundles of connective-tissue fibres. Dimples, where they occur, are due to the same cause; that is, the skin is at that point attached to the underlying tissues and does not move together with the rest of the skin of which it forms a portion.

THE STRUCTURE OF THE SKIN.—The integument of the body is composed of several layers. The most external of these consists of epithelium and is termed the epidermis. It clothes the outer surface of the corium, or cutis propria, the line of division between the two being very sharply defined owing to the great morphological difference between the elements composing each. The corium is a closely knit tissue, which consists of connective tissue, elastic fibres, and unstriped muscle. It contains the glands of the skin and the hair, and is rich in blood-vessels and in nerves. It is not sharply limited on its under surface, but goes over here gradually into the subcutaneous or fatty layer of the skin. This layer, the panniculus adiposus, is in reality the deeper portion of the cutis, and consists of connective-tissue fibres loosely put together, which contain in their cells and in the spaces between them a more or less large amount of fat.

The epidermis and the corium are the most important portions of the skin, and vary in many particulars on different portions of the body. The various appendages of the skin—the hair, the nails, and the glands—grow from and are attached to them. The complexity of all these separate constituents of the skin is, however, so great that each one requires special consideration.

EPIDERMIS. *Embryology.*—The epidermis, the most external layer of the skin, is formed from the ectoderm, and in the first month of life and the beginning of the second consists of only a single, or in its thicker portions of two or three rows of polygonal cells. Beneath these is a layer of very small cells, which represent the origin of the stratum mucosum or rete Malpighii. This increases in the course of development by proliferation to several rows of cells, the layer becoming more and more distinct and thicker. In the meantime the outermost cells have also become flatter, and thus represent the primitive horny layer, which, however, remains during fetal life of a low grade. It is subjected to constant desquamation, and the scales from its surface are mixed with the secretions from the skin to form the vernix caseosa. As early as the eighth month (Unna) granular cells begin to appear between the horny and mucous layer, and the cornification of the epidermis cells becomes more marked. Nevertheless, and before this, the horny layer has become strong enough to oppose sufficient force to the epithelial growth and to the proliferation of its cells, so that the increase in thickness of the rete Malpighii can no longer take place in the direction of the external surface, but is compelled to proceed downward toward the cutis propria. It penetrates, in its further development, into the spaces between the rudimentary papillæ which spring from the surface of the cutis, and thus forms the interpapillary prolongations of the epidermis. It is by virtue of these ingrowths of the epidermis that, when fully formed, it lies upon the derma as an accurately fitting coat, which follows closely the outlines and inequalities of the true skin.

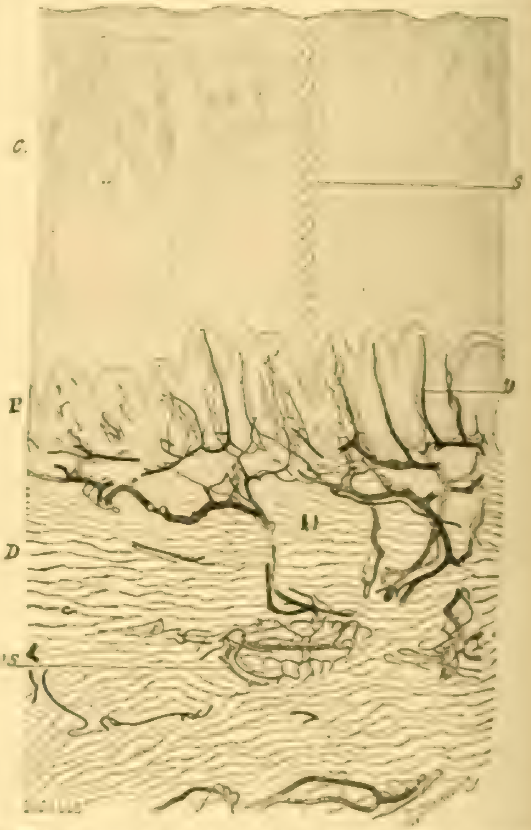

FIG. 5006.—Transverse Section of the Skin on the Palmar Surface of the Third Finger. C, epidermis; P, papillæ; D, dermis; S, sweat pore; v, vessels of the papillæ; vs, capillary net-work of a glomerulus of a sweat gland. (Toldt.)

Thickness of the Epidermis.—The depth of the epidermis, as a whole, varies from birth to old age, and also on different parts of the body. It is also influenced by external causes, as pressure, rubbing, etc. At birth it is from 0.15 mm. to 0.25 mm. in thickness, but in adult life from 0.75 mm. to 1.66 mm. The differences are due, for the most part, to the thickness of the horny layer, which in some situations, as on the palms and soles, or on any surface subjected to constant pressure, may attain a very considerable increase in thickness.

Layers of the Epidermis.—The epidermis is divided into two major layers, the division being due to the different consistency of the cells constituting each. The most external and superficial one, which consists of horny cells and is firm and resistant, is termed the stratum corneum, while the one immediately below it, which lies in contact with the derma, is called the stratum mucosum, or rete Malpighii. This latter consists of soft epithelial cells, and is sharply defined from the stratum corneum. Both of these major layers are still further subdivided according to the appearance of its cells, or to the reaction of their various portions to certain coloring substances.

Rete Malpighii.—The most deeply situated cells of the stratum mucosum, those which are in immediate contact with the derma, are cylindrical in shape and form the basic layer of the rete. Its importance can be estimated from the fact that it represents the productive part of the stratum mucosum. In normal skin they are the only cells which show the karyokinetic cell-figures, and indirect division of the nucleus occurring in epithelial growths. Their long axes are directed perpendicularly to the corium, and if the layer is carefully examined, small basic cells, resulting from the cell-division, are seen pushing their way in between the older ones. In this way the constant regeneration of the rete is provided for.

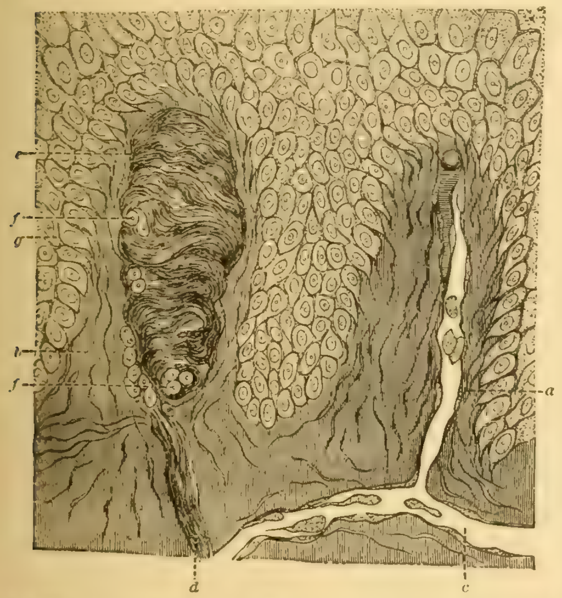

FIG. 5037.—*a*, Capillary ; *b*, papilla containing tactile corpuscle ; *d*, nerve-fibre which goes to the tactile corpuscle ; *e*, *f*, cross-section of a nerve-fibre ; *g*, cells of the rete Malpighii. (Kaposi.)

The cylindrical cells send out into the corium more or less long prolongations, but the spines, which characterize the entire rete, are seen clearly only upon their upper contours. It is in these cells, especially, that a more or less large amount of pigment granules are deposited, which give the various shades of color to the skin of different individuals and races.

Above the basic layer cells of various shapes and sizes are found. Over the papillæ, and in the interpapillary portions of the rete, round and cuboid and polygonal cells are seen. In the interpapillary prolongations, however, round cells predominate. As the external surface is approached the cells become larger, and have their long axes more parallel to the surface of the skin. The cells themselves have a body consisting of finely granulated protoplasm, which contains a clearly defined nucleus, in which are several nucleoli. According to the position of the cells in the rete, the shape of the nucleus varies. In the uppermost portions it is oval, in the middle, round, and in the cylindrical layer, rod-like, thus agreeing more or less accurately with the shape of the cell. The varying form of all of these cells is due in general to the degree of mechanical pressure to which they are subjected by the individual growth of each, and by other causes, such as atmospheric pressure. The cells composing this portion of the rete Malpighii do not lie in close contact with each other, but are held in apposition by protoplasmic prolongations from their surfaces, which are continuous with the protoplasm of the cell-body. They have been termed spines. It is due to this characteristic that the entire layer has been named the stratum spinosum.

The spines, which characterize these epithelial cells, were first observed by Schrön, and the function of binding the cells together has been attributed to them. The manner in which this occurs has, however, always been a subject of controversy. Max Schultze was of the opinion that they were arranged as in a pinion and ratchet ; Bizzozero, that their ends were united together ; and Ranvier, that their ends were fused together, forming a peculiar elastic organ which allowed considerable movement. These spines can be studied best in rapidly proliferating growths of the rete, as in condylomata acuminata ; but in the normal skin it is very difficult to form any opinion in regard to their natural arrangement. Whether the spines are active or passive in their nature is likewise a disputed point. Still, as Unna has pointed out, they are in all probability the result of active protoplasmic movement, since they are purely prolongations of the cell-body and consist of the same protoplasm.

Intercellular Spaces.—The arrangement of the spines springing from the surface of the cells of the rete is such that small spaces are left between them. These, the intercellular spaces of the stratum mucosum, are of great importance, inasmuch as they serve as channels for the passage of the nutrient fluids from the corium to the epithelium. The communication existing between the blood- and lymph-vessels and spaces and these intercellular spaces was clearly demonstrated by Nalepa, who succeeded in injecting them from the subepithelial blood-vessels. The wandering cells coming from the vessels of the cutis and seen in the rete are also enabled to wander along by means of these spaces, and they are the source of the pigment sometimes seen in these situations. When they break down they are taken up by the spiny cells.

Stratum Granulosum.—Situated above the stratum spinosum, but yet in close contact with it, is a layer of cells characterized by the possession of certain peculiarities. This layer consists of one or two rows of cells, seldom of more, upon whose surfaces shortened spines may still be seen, and they also contain granules of various sizes and shapes. It is owing to the presence of these that it has received the name of stratum granulosum. These granules react toward certain coloring substances in a marked manner, and stain very deeply. Unna, who has studied this layer very carefully, states that it makes its appearance in the epidermis toward the end of fœtal life, but that it can be seen much earlier in the inner root-sheath of the embryonic hair.

The stratum granulosum is present over the entire skin, except on the vermilion border of the lips and in the nail bed. The granules appear white by direct light, and for this reason Unna asserts that they are the cause of the white color of the Caucasian race. Such an explanation is, however, scarcely a reasonable one, owing to the fact that this same stratum granulosum is present in the skin of the negro as well as of the other dark races ; and besides, when it is found pathologically or even under natural conditions greatly increased in depth, it does not seem to cause the color of the portions where it is situated to be whiter than the remainder of the skin. The stratum granulosum is very marked in condylomata acuminata and on the palmar surface of the hands, and yet the former are far from being white in color, and the latter are not especially so.

The granules which are present in these cells have been the subject of so much discussion that they are worthy of extended consideration. They were observed long ago by Kölliker in the medulla of the hair, and by Aufhammer in the epidermis. Langerhans, however, was the first to describe them carefully, while Unna pointed out that they stood in intimate relationship to the process of cornification, and he claimed that they represented the intermediate steps which occurred in this process transforming the soft epithelial cells into horny tissue. Ranvier regarded them as drops of a fluid substance, which existed in a free state in the lowest layers of the stratum corneum, and to which he had given the name of eleidin. Waldeyer, however, has furnished the most satisfactory and correct information in regard to them. He proved that they could not be drops of fluid, because they swelled up on the addition of alkalies and also changed their shape on pressure, but not in the manner that fluids do. They were likewise insoluble in ether, alcohol, or water, and possessed a very great affinity for the nuclei-staining dyes, as hæmatoxylin, picrocarmin, etc. The supposition that they were fatty in character was also excluded by their want of reaction to osmic acid. Waldeyer found, on the other hand, that they agreed chemically very closely with the hyalin of Recklinghausen, a product of degeneration, and for this reason he suggested the name of keratohyalin for the substance.

Keratohyalin, according to Unna, is found to a small extent around the nucleus of the cells in the middle portion of the stratum spinosum, but it exists to a considerable extent only in the stratum granulosum. The granules here are small, and though the cells are filled with them, yet a small peripheral zone always remains free from encroachment. The cells in this layer have atrophied nuclei, which, however, still stain well, and the intercellular spaces are narrowed to such an extent as to be almost entirely absent.

The significance of keratohyalin and its relation to the process of cornification has received much attention. The general opinion at present is in favor of regarding these granules not as the cause of the cornification of the cells, but as a phenomenon accompanying that process, and as one which is produced by the act of cornification taking place in the periphery of the cells.

Stratum Corneum.—The layer of the epidermis lying above the stratum granulosum is the stratum corneum. It is the one which is most external and is in contact with the air. It varies greatly in thickness on different portions of the body, being, however, usually most marked on the palms of the hands and on the soles of the feet, and also being always much increased on any portion of the skin which is subjected to constant pressure. On these surfaces especially—that is, on the palms and the soles—it is noticeable that its lowest portion, that which is immediately next to the stratum granulosum, possesses great transparency. This stratum is narrow, sharply defined, and is known as the *stratum lucidum* of Oehl, but its existence has never been satisfactorily explained. The cells forming the stratum corneum are clear and transparent, showing neither granules nor nuclei. Unna claims to have found traces of the spines seen on the cells of the stratum spinosum even here, and asserts that the coherence of the cells forming the horny layer is due to their persistence.

By means of artificial digestion with pepsin and trypsin, it has also been found that the entire cell does not become cornified, but only the peripheral portions. After employment of this method it is clearly seen that it is the contents of the cells which are destroyed, while the peripheral portions remain and have the appearance of horny shells.

The reaction of the epidermis to certain staining materials allows furthermore a recognition of several layers constituting it, and shows successive changes not only in the cell substance, but also in the intercellular spaces. We owe to Unna the following table showing the reaction of the several layers of the epidermis to various dyes:

Layers of the Epidermis.		Consistence.	Osmic acid.		Picrocarmine.	Hæmatoxylin, alum, and acid.	Gentian violet (Gram-Weigert).	Safranin and [illegible] H. Hebra.
			Without removal of fatty matter.	After removal of fatty matter.				
A. Stratum Corneum.	1. Superficial.	Firm.	Black.	Clear.	Yellow.	Bluish white.	Blue.	Brown.
	2. Middle.	Looser texture.	Clear.	Dark brown.	Red.	Violet.		Clear.
	3. Suprabasal.	Firm.	Black.	Clear.	Dark red.	Bluish white.	Clear.	Light brown.
	In Basal, stratum lucidum of Oehl.	Very firm.			Yellow.		Blue.	Not constant.
			Clear.	Dark brown.				
B. Stratum Granulosum.		Soft.	Transparent.		Granules dark red.	Granules dark violet.		Brown.
C. Stratum Spinosum.	Rete Malpighii, stratum of Purkinje.		Greenish grey.		Nuclei colored red.	Nuclei colored blue.	Nuclei and [illegible] blue.	Light brown.

The several layers which have just been described as entering into the formation of the epidermis should be carefully considered in the study of the anatomy of the skin. It is from the epidermis that the appendages of the skin, the hair, the nails, and the glands originate and derive their most important parts. We shall refer to this again when describing these various constituent portions of the skin.

THE CORIUM, DERMA, OR CUTIS PROPRIA. *Embryology.*—The corium, or true skin, is that portion which lies between the epidermis and the subcutaneous or fatty layer. It is derived from a superficial portion of the mesoderm, consisting at first of only round cells. In the second month of fœtal life, however, spindle-shaped cells begin to appear, but only very little intercellular substance is present. Very shortly after this it is noticed that the cells in the upper portion of this primitive corium become more closely aggregated together than in the lower portion, and at the same time the formation of fibrillated tissue begins in this latter. The fibres increase greatly in number, and by the fourth month the presence of fat is detected. It is in this way that the subcutaneous or fatty layer is developed, and it is to be considered as, in reality, a part of the derma, since it has the same embryological source, and not as a separate and distinct layer of the skin. The transformations which take place among the closely aggregated cells in the upper portion are shown by the penetration of fibres between them and by the deposition of collagenous material. The individual cells are thereby more and more widely separated from each other, and the corium attains a considerable degree of thickness. Gradually blood-vessels and nerves pass into it, and upon its superficial surface the papillæ begin to form. These latter appear about the sixth month of fœtal life as small eminences upon the surface of the cutis. They are formed by the growth of the epidermis, which pushes before it the weaker and more yielding portions of the cutis. They are first seen on the palms of the hands and the soles of the feet, but are quite general toward the end of fœtal life. The development of the papillæ is not fully completed until after birth.

Histology of the Cutis.—The major part of the cutis consists of fibrous connective tissue, which is poor in cells and which is arranged in the form of bundles. The texture of the cutis is closely knit in that portion next to the epidermis, but is much looser in the parts below this. In this situation, the fibre-bundles crossing each other form the rhombic spaces, which have been mentioned as the cause of the linear cleavage of the skin. On account of the difference in the texture of the cutis, it has been divided into two layers: the one in immediate contact with the epidermis being termed the pars papillaris, that below it, the pars reticularis.

Pars Reticularis.—The pars reticularis of the corium is composed of bundles of fibres of various sizes and length. They are continuous with the connective tissue of the inner portions of the body—the fasciæ, etc.—and pass upward perpendicularly, or slightly inclined to the surface of the skin, until they arrive at the cutis. Here they run obliquely, crossing each other at various angles, and serve as boundaries for spaces, which are formed by their intersection. These spaces are, in general, rhomboidal in shape, but oftentimes polygonal, their regularity depending upon the length and uniformity of course of the fibre-bundles forming them. The length of the fibre-bundles and the absence of their firm adhesion to the underlying tissues is a very important factor. It is owing to such an arrangement that the skin is freely movable over the greater portion of the body. On the scalp, the palms of the hands, and the soles of the feet, where these bundles of fibres are short and intimately united to the underlying fascia, the skin is only very slightly movable. These places of intimate union, however, serve as fixed points from which the skin is stretched over the body. The movability of the skin is also limited on the circumscribed portions, where it is in immediate contact with bone, cartilage, or tendons, as over the tibia, etc.

The bundles so frequently mentioned are composed of fibres, which correspond in structure to those of fibrous connective tissue. Under normal conditions they are in a state of tension, and are for the most part straight, but under the microscope they are found presenting a wavy appearance. Chemical examination has shown that they consist, to a great extent, of collagenous material. The fibres themselves are bound together in bundles by an albuminous semifluid cementing substance, which Rollet has found to be similar to mucin. According to Fleming, this cementing substance exists not alone between the fibres, but also surrounds the bundles, and Tomsa claims that it binds together all the constituents of the cutis.

The fibres possess cells, but they are numerous only in the vicinity of the large blood-vessels. These cells are the usual connective-tissue cells; they are large and contain nuclei and nucleoli. They lie upon the bundles in the same manner as endothelial cells do in the situations where these are found, and for this reason have at times been considered as forming an endothelial lining for the rhombic spaces between the bundles. It has, however, been demonstrated that they differ from the cells of endothelium in that their edges do not lie in contact with each other, and they do not form a continuous covering for the bundles (Ranvier).

Elastic tissue. According to the latest investigations made in regard to the elastic fibres of the skin—a most thorough study of which has been made by Unna—they are exceedingly abundant in the reticular portion of the cutis. By the use of special methods of staining and of preparation, Unna found that, under the form of broad bundles, elastic fibres spring from the fascia below the skin, and, passing up between the fat masses, penetrate into the cutis. In their course they divide continually in a more or less forked manner. These bundles may be traced upward to just below the epidermis. The muscles of the cutis also serve as points of origin for bundles of elastic fibres, and Unna claims that they can be seen attached to the muscles at their points of origin and insertion, having a tendon-like appearance.

Another relatively fixed point of the elastic basework of the cutis is seen in an extensive net-work of fibres, which follows with the greatest regularity the outline of the epidermis, where this latter is in contact with the corium. This net-work, which Unna terms the subepithelial elastic net, is situated just below the surface of the cutis, being separated from the epidermis by a narrow homogeneous strip of the derma, in which there are very few blood-vessels. From this net-work fine fibres are given off, which proceed upward perpendicularly and are lost sight of here and there between two of the basic epithelial cells of the epidermis.

There is, also, in the papillary portion of the skin an extensive net-work of elastic fibres. It is formed by the repeated division of fibres which originate from the subepithelial net-work. All of these elastic fibres do not exist independently of the rest of the cutis, but are more or less closely connected with the fibre-bundles of connective tissue which have already been treated of.

The relationship of these elastic net-works to the appendages of the skin, such as the hairs and glands, has not yet been thoroughly studied. Still Unna claims that there is some special connection between them and the sweat ducts and glands. The elastic fibres are found to be entirely absent around the coils, but quite abundant about the ducts, along which they run in a parallel direction. He consequently is of the opinion that the contraction of the elastic net-work of the skin, acting with the fibre-bundles with which it is in close union, produces a pressure on the ducts, and shortens them by diminishing the thickness of the skin. In this way the passage of the secretion of the glands through the ducts to the outer surface is favored.

Unstriped muscle. With the exception of the palms of the hands and the soles of the feet, the skin of the entire body contains a more or less large number of unstriped muscular fibres and bundles. They are found to attain their highest development in the skin of the scrotum, in the penis, the nipple, and its areola. The vermicular movements of the scrotum are due to these involuntary muscles, as is also the erection of the nipple. They are situated in the cutis propria, and lie perpendicular to the plane of cleavage of the skin. On the penis they are arranged in a circular manner, and they follow a similar course in the nipple and in its areola.

Besides these, there are other muscles in the cutis which, owing to the connection existing between them and the hairs, are termed the arrectores pili. They are formed by the union of several small muscular bundles, which, originating in the pars papillaris, run an oblique course through the reticular portion of the cutis, and are attached to the hair-follicle. The point of their attachment is not uniform—sometimes to the middle portion of the hair-sheath, sometimes low down in the lower third. It will usually be observed that, in their course to their point of attachment, they curve around the sebaceous gland attached to the hair-follicle and are in quite intimate connection with it. According to Tomsa, the fixed point of the arrector muscles is the hair-follicle, while the point of movement is the pars papillaris of the cutis.

The arrangement of the involuntary muscular fibres in many places in the derma, as in the cutis of the forehead, cheeks, back, is in the form of a net-work. This net originates in the pars papillaris and is distributed throughout the upper two-thirds of the pars reticularis. By the action of these muscles the skin is kept more or less in a condition of tension. According to the direction in which they exert their action, the muscles have been divided into horizontal and oblique tensors. The elastic bundles and fibres connected with the muscles play here an important part, inasmuch as Tomsa has shown that they stand in the same relationship to them as do the tendons to the voluntary muscles, and serve as fixed points from which the contraction of the cutis tensors takes place. The action of these muscles also regulates to a great extent the circulation of the lymph in the cutis, while the contraction of the arrectores elevates the hair, compresses the sebaceous glands, and facilitates the propulsion of their secretion into the hair-follicle.

The Pars Papillaris Cutis.—The papillary portion of the true skin is constituted by a series of small eminumber of papillæ which spring from its upper or free surface. It is in direct contact with the epidermis, which, as has already been described, sends down prolongations of epithelial cells between the papillæ; but the line of demarcation between them is most distinct, owing to the difference between the elements composing each.

The papillæ of the skin are found most fully developed on the palms of the hands and on the soles of the feet. They are arranged here in long double rows, which form the curvilinear ridges seen in these situations. Between these rows there is a narrow path in which are the external orifices of the sweat-ducts. On other portions of the body the papillæ are arranged more or less in groups or in short rows, and the surface of the cutis seems to be divided into rhomboidal spaces of various sizes by the deeper penetration of the interpapillary prolongations of the epidermis. The long diameters of these spaces agree with the lines of cleavage of the skin where they are situated, and their shape is dependent upon the arrangement of the connective-tissue bundles in the reticular portion of the cutis.

The papillæ are more or less conical in shape, sometimes simple, or again cleft into two or more points, forming a compound papilla. They differ greatly in shape, size, and distribution on the various portions of the body, and also vary according to the age of the person (Unna), becoming in old age almost flat. They are very numerous on the penis, the nipple, the labia minora, and the clitoris, appearing in these places as low hills. The largest papillæ are found in the cutis of the nipple and of the corona glandis. Those distributed generally over the surface of the body are very small, about 0.05 mm. in height. On the ends of the fingers, under the free borders of the nail, they attain a size of 0.5 mm.; but their height varies in general between 0.05 mm. and 0.2 mm.

The papillary portion of the cutis consists of a closely woven network of fibres, which are derived directly from those forming the pars reticularis. The papillæ are very rich in elastic fibres, and contain blood-vessels, lymphatics, nerves, and, in certain situations, tactile corpuscles. The manner in which the papillary body and the epidermis are joined together, must be studied on specimens which have been macerated, and from which the epidermis has been removed *in toto*. When this has been done it is seen that the entire surface of a papilla has a finely ribbed aspect. On sections made horizontally through them, they look as though their contour was toothed. The ribs have a slightly wavy course and are at times arranged in a concentric manner, having much the same appearance as may be observed on the palmar surfaces of the ends of the fingers. These ribs on the papillæ have been found to correspond to minute furrows on the cells forming the basal or cylindrical epithelial layer of the epidermis, and to fit into them, each cell requiring usually three or four ribs. From the fibrillated appearance it might be thought that these ribs were connective-tissue fibres, but such has not been found to be the case. They consist in reality of a transparent homogeneous substance, which covers thinly the surface of the papillæ. The proof that it is a distinct membrane has never been satisfactorily made, and it seems better to accept Unna's view, that it stands in intimate connection with the cementing substance of the cutis in general, since it has been found that when the cutis is subjected to the action of trypsin, this homogeneous substance covering the papillæ disappears in the same way as the cementing substance in other portions of the derma. The blood-vessels, etc., in the papillæ will be treated of in their appropriate place.

THE SUBCUTANEOUS CONNECTIVE TISSUE OR FATTY LAYER.—It was mentioned, in speaking of the embryological origin of the skin as a whole, that the subcutaneous or fatty tissue was derived from the mesoderm. It is that portion which attains its full development the earliest of all the layers of the skin, and in which the deposition of fat between the fibres constituting it takes place very early in fœtal life. The subcutaneous connective tissue, or panniculus adiposus, though in reality the lower portion of the corium, is regarded as forming the third layer of the skin, and it is characterized by the presence of a greater or less amount of fat deposited within its meshes.

It is composed of bundles of connective-tissue fibres, a network of elastic fibres, and fat, and is very rich in large cells. These have long poles and are situated either in or between the fibre-bundles, occurring in the form of spindle-shaped cells. According to Flemming, the masses of fat can be divided into three classes, each of which is characterized by its blood-supply: the fat-clusters with their own blood-vessels; the strands of fat which lie around the large vessels and receive only a meagre supply of blood from capillaries; and the fat-islands which have no blood-supply of their own. We have to thank the same investigator for our knowledge of the histology of fatty tissue. He found that the fat-cells were derived from ordinary branching connective-tissue cells. They took up fat in small drops, and in proportion as the fat increased in quantity the protoplasm of the cells also increased, and they became round in shape. The protoplasm containing the nucleus is forced to the periphery by the accumulation of fat, and appears as a membrane; but these fat-cells have no true enclosing membranes, except when they are old, and when the protoplasm has become thickened into a membrane-like covering. The contents of the cells do not consist of pure fat, but of a mixture of fat and of some product from the protoplasm. At the time of birth the panniculus adiposus is very greatly and uniformly developed over the entire body. As the child grows, however, it diminishes in quantity and remains of considerable extent only on certain portions. Its function is protection to the underlying tissues, and it serves to give roundness to the outline of the body. Those portions of the body which are firmly bound down to the fascia by short bundles of fibres, as the scalp, the skin of the palms and of the soles, etc., possess only a small fatty layer. Where great mobility is necessary, as in the eyelids, or where there is a great amount of muscular tissue, as in the scrotum, the panniculus adiposus is also absent. Over the joints, where the skin lies in close contact with the bones and by their movements is continually subjected to pressure and tension, bursæ develop in the subcutaneous tissue after birth. In this layer the large arterial and nerve trunks going to the cutis are found, and also the veins and lymphatics which come from the derma and unite to form large efferent branches. In certain localities the Pacinian bodies are also present.

THE GLANDS OF THE SKIN.—There are two sets of glands which are found in the skin, the sweat glands and the sebaceous glands. They differ from each other to a most marked degree, and if considered from the stand-point of their relative importance the former claim priority and more extended study. We shall, therefore, begin with the sweat glands.

THE SWEAT GLANDS. *Embryology.*—The primary evidences of the development of these glands of the skin are seen in the fifth month of fœtal life. They appear first on the palms and on the soles under the form of rows of epithelial prolongations from the inferior border of the epidermis into the cutis. At this stage they are solid, club-shaped, and surrounded by a homogeneous membrane. Their further development consists in the elongation of these epithelial ingrowths downward, and in the formation, by the seventh month, of a cavity along its axis, which is later further extended through the epidermis to the external surface. In the meantime the gland tube at the end in the cutis has become coiled up, forming a ball, and the excretory duct in its course through the skin is twisted upon itself. The development of these glands is very rapid, and by the end of fœtal life they have already attained their full development. In certain situations, however, they enlarge even after birth, and in their structure differ somewhat from the ordinary and smaller ones distributed generally over the body. These larger glands are found in the axillæ, the inguinal regions, around the anus, the nipple, and in the auditory canal (ceruminous glands).

The sweat-glands are present everywhere in the integument of the body, with the exception of the glans penis, the under-surface of the prepuce, and the vermilion border of the lip. They are small bodies, consisting of a convoluted tube and an efferent duct which leads to the external surface, and they are situated in the corium or even in the subcutaneous connective tissue. They vary greatly in size. The coils of the large ones situated in the axilla are from 1 mm. to 2 mm. in diameter; the smaller ones on the general surface are from 0.2 mm. to 0.3 mm. They are most numerous on the palms of the hands, Krause estimating that there were 2,800 orifices in a square inch on those surfaces.

The sweat-glands, as a whole, are composed of two distinct portions, a secretory and an excretory. The former is represented by the coils, the latter by the duct which leads to the external surface of the skin. The histological anatomy of the smaller glands differs somewhat from that of the larger ones, and will be considered first.

Histological Anatomy.—The coils, or secretory portions of the sweat-glands, consist of a single layer of columnar epithelium, arranged around a rather irregularly shaped lumen. The cells are cloudy throughout, with the exception of a narrow portion along their free margin, which is clear. They are bounded externally by a layer of involuntary muscular fibres, which run spirally around the mass of cells, and which are so arranged that small spaces are left between them. The secreting-cells send out processes into those spaces, and these form a union with the limiting membrane or membrana propria of the glands, which is composed of connective tissue. The excretory portion of the gland, or duct, consists of a connective-tissue coat, a structureless membrane, and bounding its lumen are two rows of epithelial cells, the free margins of which are covered by a cuticula. There are no muscle-fibres in the coats of the sweat-ducts. These latter begin in the inner portion of the coils, and rise to the surface in an oblique direction having a more or less spiral course, and they always reach the epidermis at an interpapillary prolongation. The duct here loses its membrana externa, which goes over into the tissue of the papilla, and also its cuticula, so that the lumen is bounded for a short distance in the stratum spinosum by the spiny cells alone. The cells which limit the lumen in its course through the epidermis, show granules of keratohyalin very early, and considerably below the level of the stratum granulosum; and it can further be seen that all the layers of the epidermis become interested and aid in forming the boundaries of this spiral canal in its course to the external surface. The views which are held by Unna, in regard to this portion of the duct, have so much in their favor as to claim general recognition. He does not consider that the spiral portion in the epidermis belongs entirely and alone to the duct of the sweat-gland, of which it seems to be a continuation, but thinks that it is a canal which is also in connection with the system which conveys the juices throughout the epidermis. According to him, the sweat-duct ends in the basic layer of the stratum spinosum, and he would, consequently, separate the two portions very sharply. He very rightly points out in support of this, that we have no reason for concluding that the fluid which passes through it comes entirely from the same source, inasmuch as there are no grounds for asserting that the sweat is derived from the coils alone. All that we do know is, that it appears upon the external surface at the openings of these canals, but more than that has not been proved.

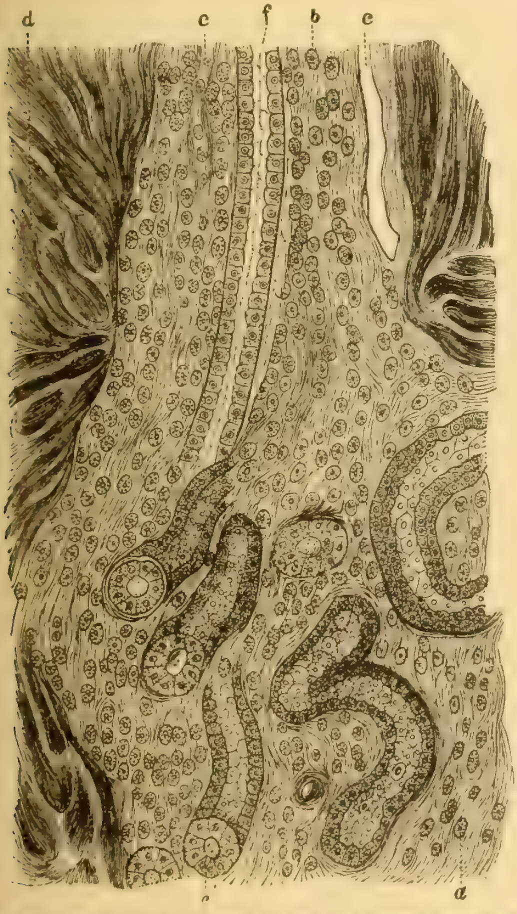

FIG. 5038.—Sweat Gland and Duct, as seen in a Section Perpendicular to the Cutis. *e*, Cross-section of a coil; *f*, lumen of duct; *c*, *c*, blood-vessel accompanying the duct; *d*, connective-tissue bundles; *a*, *b*, cellular infiltration of the cutis (pathological). (Kaposi.)

The histological anatomy of the larger sweat-glands, as has been already mentioned, differs somewhat from that of those just described. The differences are shown both in the coils and in the duct, by a dilatation and a narrowing of the canal in places. Where the lumen is larger there is only a single layer of epithelial cells; but in the narrower portions there are several. It is also claimed that muscle-fibres are present in the former situations, but they are always absent from the latter.

THE SEBACEOUS GLANDS. *Embryology.*—The sebaceous glands of the skin make their appearance from the beginning of the fourth to the fifth month of pregnancy (Gegenbauer). Those glands, which open directly upon the external surface of the skin, are formed from ingrowths of the rete Malpighii, which penetrate into the cutis. These epithelial prolongations are at first solid, but a canal soon forms in them by the fatty degeneration of the central cells. In its further development it is found that, by a process of cell proliferation, solid buds are given off from the original epithelial ingrowths, canals form in the axes of these, and the gland, finally consisting of several lobules, has become racemose. The origin of the sebaceous glands attached to the hairs is the same, except that the epithelial ingrowths proceed from the external root-sheath of the hair. They appear very soon after the formation of the hair-follicle by the prolongation of the rete into the cutis.

Distribution and Size.—The sebaceous glands are distributed very generally over the body, and are found everywhere in the skin, except upon the palms of the hands, the soles of the feet, and the last phalanges of the fingers and of the toes. They are particularly numerous upon the face and the scalp, where they are set very closely together. On the rest of the body they are found to be fewer in number and more widely separated. The glands vary very greatly in size. Of those connected with the hairs, the smallest are the ones on the scalp, 0.1 mm. to 0.16 mm. in diameter, but larger ones are attached to the hairs of the beard and axilla, from 0.16 mm. to 0.24 mm.; but the largest are on the mons veneris, the labia majora, and the scrotum. The sebaceous glands which are in connection with the lanugo hairs are from

0.25 mm. to 1 mm. in diameter. The length of the glands is from [illegible], but the large ones on the nose measure even as much as 1 mm.

In shape there is also considerable variation. The simplest ones resemble small pouches, but the glands are usually found to be racemose or acinous, that is, composed of several lobules which possess one duct in common.

These glandular bodies are situated for the most part in the upper portion of the corium above the level of the coils of the sweat glands. Some extend, however, through almost the entire thickness of the cutis.

They are found either directly attached to the hair-follicles, into which their ducts open at a variable distance from the orifice on the cutaneous surface and empty the fatty matter secreted by them, or the external opening of their ducts is situated on the surface of the skin. These latter are the glands with which the lanugo hairs are associated. Besides these two forms there are others which are entirely unconnected with hairs and which also open directly upon the outer surface of the skin.

The sebaceous glands which open into the cavity of the hair-follicles are the most numerous. They are seen wherever fully developed hairs exist, as on the scalp, the beard, etc. There is sometimes only one gland, but more often two, situated on opposite sides of the follicles, of different sizes, and at different heights. Their excretory ducts are short and pass obliquely upward to enter the follicles, the larger glands opening more superficially, the smaller ones more deeply, but the common location is at the junction of the upper and middle thirds.

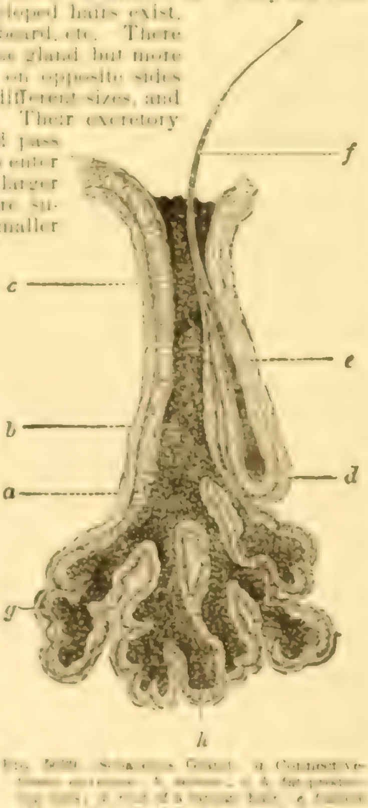

Fig. [illegible].—Sebaceous Gland. a, Connective-tissue envelope; [illegible] hair; f, shaft of hair; g, [illegible] of the gland. ([illegible].)

The sebaceous glands which are associated with the lanugo hairs and which open directly upon the external surface are distributed over the forehead, cheeks, sides of the nose, and alæ especially. They occur also more or less scattered over the trunk, the extremities, and the genitals. These glands are the largest and also the most complicated in their structure. The duct is usually broad and its orifice dilated. The hair attached to it is really an appendage and passes through the duct to reach the outer surface of the skin. It has no follicle of its own, except at its deepest portion.

The glands which are in no way associated with hairs, and which open directly upon the external surface, are rather seen situated in special localities. They have received distinguishing names, and are known as the Meibomian glands in the eyelids, and the glands of Tyson on the glans penis and prepuce. To this class also belong the large glands of the labia minora, and those of the vermilion border of the lip.

Histological Anatomy.—A sebaceous gland may be considered as composed of an outer wall and an inner mass of cells. The wall is formed of connective tissue, which is derived from the external sheath of the hair-follicles; but in those glands associated with the rudimentary or lanugo hairs, and in those unconnected in any way with hairs, the fibrous envelope is obtained from the corium. The wall acts as a support [illegible] for a basement or membrana propria, which bears upon its inner surface a layer of cylindrical epithelial cells, and it also contains the nerves, blood-vessels, and lymphatics supplied to the glands. The membrana propria is exceedingly thin and amorphous. The single row of cells which are in connection with it is a continuation of the basic layer of the epidermis, the spiny cells stopping at the neck of the glands. The cavity of the glands is filled with large oval and polyhedral cells having large nuclei, but in the central portions there is a semifluid homogeneous mass, the sebum. The source of the sebum seen in the sebaceous glands are the cells, which are found presenting all stages of fatty degeneration. The most external ones are granular, the succeeding ones contain small drops of fat, which gradually increase in size as the central portion of the cavity is reached, until there is no trace of protoplasm remaining, the cell being completely filled with fat.

THE BLOOD-VESSELS OF THE SKIN.—The vessels which supply the skin with blood are branches from the larger arteries which lie below the subcutaneous fatty tissue. They pass up through this latter and form at its junction with the corium a more or less horizontal net-work. From this net-work further branches are given off, some to supply certain portions of the skin, others to ascend obliquely and perpendicularly through the cutis, having only few branches, until they reach the subpapillary layer of the corium. Here they again form a more or less horizontal net-work, which also gives off many branches.

The plexus of arteries at the junction of the cutis and subcutaneous tissue is very rich. It supplies the papillæ of the hair, the coils of the sweat glands, and also sends off branches which break up into capillaries in the panniculus adiposus. The subpapillary net-work of arteries supplies vessels to the external root-sheath of the hair, the sebaceous glands, the unstriped muscles, and the ducts of the sweat-glands. In addition, this plexus gives off branches which break up into capillaries just below the papillæ, and into each of these a tortuous arterial capillary ascends almost to its upper end, where it forms a loop and goes over into a venous capillary. These latter unite to form venules in the same plane as the arteries, and course along them. When they arrive at the subcutaneous layer they, together with the veins from the other portions of the cutis, unite to form large venous trunks in the same plane as the large arteries. Between the two horizontal plexuses of arteries there is a portion of the cutis which has a very poor blood supply, and here even the bundles of fibres which go to form the pars reticularis do not receive any vessels.

There are considerable differences in the distribution of the blood-vessels of the skin, and the area supplied by any one branch. These areas are very small on the palms of the hands, the soles of the feet, and the face, also at the sulcus coronarius and the corona glandis; in which places each branch from the subpapillary arterial plexus, when it breaks up into capillaries, supplies only a few papillæ. The areas which are furnished with blood by one arterial branch are much larger in the greatest part of the skin—the vessels breaking up into a number of capillaries—and it is in general observed that they are more extensive on the extensor than on the flexor surfaces of the extremities.

Peculiar circulatory conditions are found in certain portions of the skin. On the ear, the alæ nasi, and in the region of the lips, large lacunæ are seen into which the venous capillaries empty from above, while from below the venules are given off. On the ends of the fingers there is likewise a special arrangement of the vessels. It has been found that here some branches of the digital arteries empty directly into the large veins of the bed of the nails, without there being any intervening capillaries. And also it is observed that, after the vessels for the panniculus adiposus and sweat-glands had been given off, but before the upper horizontal plexus for the supply of the papillæ had been formed, small arterial branches divided and broke up into many small coils. In the inner portion of these they emptied directly into venules.

The lumen of the arteries of the skin is narrow, but the veins are large and wide. Their coats are slightly marked in the cutis, and they show only near the subcutaneous connective tissue an adventitia and a media. But even there these are poorly developed. All the vessels of the papillary layer of the corium are capillary in character, that is, simple endothelial tubes.

THE LYMPHATICS.—There are in the integument of the body two forms of channels which contain the lymphatic fluid, and through which it flows, viz., the lymphatic vessels proper, those which possess an endothelial lining, and the numerous spaces which occur between the elements composing the various layers of the skin.

In regard to the latter, it has been proved that they are the origin of the lymphatic system of the skin, through the successful injection of the intercellular spaces in the spiny layer of the rete Malpighii from the lymphatics of the subcutaneous connective tissue (Retzius, Axel Key, et alii). Other lymph-spaces exist between the membrana propria and the secreting cells of the coils of the sweat-glands, and between the epithelial cells of the sweat-ducts. The intercellular spaces in the stratum spinosum of the hair-follicles and in the sebaceous glands are also points of origin for the lymphatics. The bundles of unstriped muscle-fibres and the coils of the sweat-glands also are situated in large lymph-spaces. In the same way, the bundles of connective-tissue fibres forming the cutis are sheathed by lymph-spaces, as are also the fat-clusters. According to Klein, very fine channels proceeding from these lymph sheaths penetrate into the latter and ramify between all the fat-cells of which they are composed.

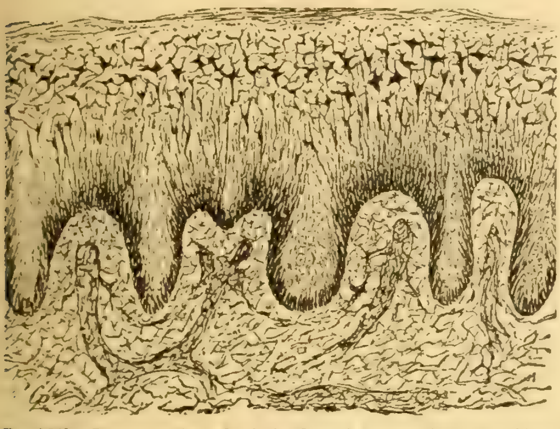
FIG. 5040.—Demonstration of all the Lymph-spaces of the Papillary Body and of the Epidermis. (Ziemssen.)

The papillæ are also extensively traversed by lymph-spaces, which empty into the lymphatic vessels proper. These vessels are lined with endothelium, and begin in the upper third of the papilla (the Hoggans) by means of a cul-de-sac. They course downward in the form of a plexus through the cutis, and at its junction with the subcutaneous connective tissue unite to form a few large vessels, which, according to Heming, have a muscular coat.

THE NERVES OF THE SKIN.—The nerves which are supplied to the skin are derived from branches of the cerebro-spinal system. They pass up through the subcutaneous connective tissue, in the same manner as the blood-vessels, from the larger trunks situated below. In the upper part of the panniculus adiposus the course of the nerves is a horizontal one, and they give off a large number of small branches for its innervation. They penetrate the cutis together with the arterial vessels, and accompany them more or less in their distribution. In their course they give off branches to supply the various constituent portions of the cutis. Those which supply the hair-follicles pass to them in the neighborhood of the sebaceous glands, to which they send fibres. They penetrate the hair-sheath and are distributed between the cells of the root sheaths. The sweat-glands and their ducts are also furnished with nerves which lie in close contact with the latter. Unna claims to have seen nerve-endings between the secretory epithelial cells of the coils.

When the nerves arrive at the upper portion of the cutis they take a horizontal course and form a rich plexus just below the epidermis, which gives off a great number of branches. These break up into fine fibrillæ, and are distributed in every direction. These fibrillæ terminate either in the endothelium of the papillary blood-vessels, or free in the connective tissue of the papillary body, or penetrate into the interepithelial spaces of the stratum spinosum. Longer branches from this plexus ascend into the papillæ, and in certain portions of the integument end in the tactile corpuscles.

The nerve-fibres which, it is claimed, have been traced between the cells of the epidermis are non-medullated. They are said to be distributed generally throughout the rete Malpighii, as far up as the stratum granulosum, and to end in the intercellular spaces, either tapering to a point or with a small rounded extremity. Unna claimed that they terminated in small disks upon the cells, but his view has not received recognition.

Besides the above-mentioned ways in which the nerves end in the skin, there are special forms of termination. These are represented by the tactile corpuscles, the tactile disks of Ranvier, the Pacinian bodies, and the end bulbs of Krause.

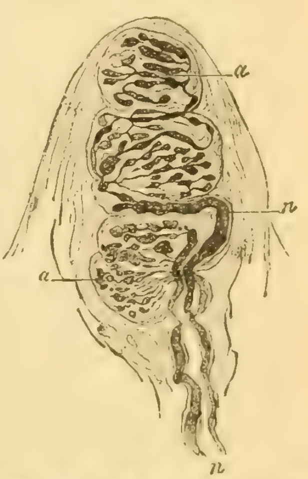

FIG. 5041.—Tactile Corpuscle. *a*, *a*, Glomeruli; *n*, *n*, afferent nerve-fibres. (Ranvier.)

Tactile Corpuscles.—The tactile corpuscles are very small, oblong bodies from 40 to 200 μ in length, and from 30 to 60 μ in breadth. They are situated in the upper portion of a broad papilla, and are found especially on the fingers and toes, and in the palm. They have a distinctly striated appearance, and are directly connected with one or two medullated nerve-fibres which wind around the corpuscle, and, on entering it, lose their medullary sheath, the perineurium becoming continuous with the capsule of the corpuscle. The nerves split up into branches, which end in flattened knobs between the connective-tissue cells of which the corpuscle is composed. They often consist of two or three sections lying close together, each one being supplied with a nerve.

Ranvier's Tactile Disks.—These disks are small cup-shaped bodies, the concave side of which is always directed toward the free surface of the epidermis. At several points on the convexity of the disk the termination of a non-medullated nerve-fibre is seen. Ranvier claims that this nerve ends only on the surface of these disks, but according to others this takes place in the cell between the nucleus and the external membrane. This form of nerve-ending has been found in the deeper portions of the epidermis, near the sweat-duct, and in the corium just below the rete.

The Pacinian Bodies.—The Pacinian bodies were first thoroughly described by Pacinius, though they had already been mentioned by Vater over a hundred years ago. They are small, oval, transparent bodies from 2 to 4 mm. long and 1 to 2 mm. broad, and are situated in the subcutaneous connective tissue, almost exclusively upon the branches of the nerves which supply the skin of the palms of the hands and of the soles of the feet, but also upon the dorsal nerves of the penis and of the clitoris. They are likewise found in other places, as around the joints, where they are deeply situated, and also in the mesentery, etc. The major part of the Pacinian body is formed by the capsule. This capsule is derived from the perineurium of the nerve which ends in the corpuscle and is in reality composed of a large number of concentrically arranged lamellæ, which are separated one from the other by a layer of flat endothelial cells. Between each of these there is a more or less large quantity of an albuminous fluid, and connective-tissue fibres forming septa are also seen. This laminated and concentrically arranged capsule surrounds a narrow cylindrical space, which contains a granular substance in which a few cells are seen, and the termination of the nerve fibre. At its entrance into the cavity of the Pacinian body, the nerve loses its medullated character and the axis cylinder alone passes in. It appears as a pale, finely granular, narrow band, which ends in a single small knob or in a series of them. The nerve has also been observed to pass entirely through one of these bodies and end in another. A small artery penetrates the capsule of the Pacinian bodies along with the nerve and forms a capillary plexus between the peripheral lamellæ.

End-bulbs of Krause.—The end-bulbs of Krause are minute oval or cylindrical bodies, which are regarded as being more or less related to the tactile corpuscles. They consist of a connective-tissue capsule containing a large number of cells which form a core. Between these, one or more nerve fibres end. They are found in the conjunctiva and the mucous membranes of the mouth, the glans penis, clitoris, and vagina, where they are termed genital corpuscles. The capsule of these end-bulbs is derived from the perineurium, but the nature of the core which it contains is still a mooted point. The axis cylinder alone penetrates into this core, having lost its medulla, and it ends in the upper portions either free, or as a small button-like protuberance.

THE APPENDAGES OF THE SKIN. THE NAILS.—*Embryology.*—The first steps in the development of the appendages of the skin, which are called the nails, and which are found on the last phalanges of the fingers and of the toes, occur in the third month of fœtal life and consist in the marking out of the nail bed and furrow. This is covered by the ordinary stratum corneum of that period of life, and it represents the eponychium of Unna; underneath the eponychium the embryonic nail remains up to the fifth month. According to Kölliker, there appears in the fourth month, between the eponychium and the stratum mucosum, a layer of large, pale-colored, horny plates, which cover the bed of the nail and represent its primary form. The nail in its further growth increases in thickness quite rapidly, possesses a free border in the sixth month, and by the seventh month is fully formed. Kölliker also claims that the development of the nail takes place from the entire nail bed, but Unna insists that he has observed the formation of a germinal spot in the matrix, from which the embryonic nail grows and pushes itself forward beneath the eponychium.

General Characteristics.—The nails of human beings are elastic structures of a horny texture which occupy the dorsum of the last phalanges of the fingers and of the toes. Each one is convex upon its external surface, concave upon its internal, and moulded upon the cutis to which it is firmly adherent. The exposed portion of the nail is called its body, the anterior extremity, the free edge; the semilunar portion posteriorly, which is of a white opaque color, the lunula. The portion of the cutis upon which the nail is situated is the nail-bed. It is bounded laterally by two folds of the skin, which are known as the walls of the nail. Around the nail-bed is a groove which is covered by the nail wall, and in this lie the lateral edges of the nail, while the posterior portion, the nail-root, is implanted in a similar though much deeper groove; this latter represents the matrix, and it is from here that the growth of the nail takes place.

Histological Anatomy.—The bed of the nail consists of the corium and the stratum mucosum. The connective-tissue bundles of the cutis run here partly longitudinally and parallel to the axis of the fingers, partly in a perpendicular direction from the periosteum to the external surface. The epithelium covering the corium is composed of cells identical with those in the stratum mucosum of the epidermis, and is sharply defined from the nail, except at the matrix.

The corium at the matrix of the nail shows a well-developed papillary body, and is very vascular, each papilla receiving a blood-vessel. In front of this and beneath the lunula the papillæ are very small, and still more so anteriorly; the cutis forming the nail-bed has no papillæ but fine longitudinal ridges in which run the blood-vessels, which give off capillary branches at regular intervals. These ridges of the corium are covered by the epithelial cells of the stratum mucosum, which also dips down between them.

The nail itself consists of horny lamellæ, which are closely bound together, and which are composed of cells similar to those of the epidermis, except that they contain nuclei.

In the formation of the nail the matrix plays the important part, and it is from this portion that regeneration of the nail is continually going on.

THE HAIRS. *Embryology.*—The hairs show the first steps in their development at the end of the third or the beginning of the fourth month of fœtal life. These are manifested by the formation of small, solid prolongations of the rete Malpighii, which penetrate into the cutis and which are increased in length by the proliferation of the cells composing them. Arriving in the deeper portions of the cutis, the lower end of the prolongations is very soon surrounded by an aggregation of round and spindle cells, which partly form the papilla of the hair and partly grow around the epithelial ingrowth in order to form the sheath of the hair follicle (Unna). During this time changes also take place in the epithelial column. In its inner portion a conical-shaped mass of cells, with its apex directed externally, becomes differentiated from the remainder, and this represents the primitive hair-body. From it the hair and its inner root-sheath are formed. The primitive hair-body having grown around the newly formed papilla, it increases in length upward, and keratinization begins and proceeds from above downward. The external root-sheath is constituted by the portions of the epithelial ingrowth of the rete Malpighii which remain after the differentiation of the primitive hair-body and then surround the entire hair.

From the sixth to the eighth month of life the fœtus has become covered with hair, which, however, falls out and is replaced by new hair. This regeneration of the hair on the fœtus is continuous as in adults, but the rapidity of the change ceases a few weeks after birth. The embryonic or lanugo hairs, which have a much shorter length of life than those which grow after birth, give place to more permanent ones, and on certain portions of the body acquire a much greater development than they do on others. The new hairs originate from the epithelium forming the external root-sheath of the lanugo hairs, which sends out solid buds from which the hair develops in exactly the same way as has just been described, and grows up alongside of the embryonic hair to the external opening of the follicle. The old hair has, in the meantime, been separated from the papilla and become completely horny, owing to its loss of nourishment, and being pushed upward by the new-formed hair falls out when the external surface is reached. In this way the temporary hairs are replaced by the permanent ones, and an entirely similar procedure is furthermore constantly seen repeating itself, even in adults.

General Characteristics.—The hairs, which are modifications of the epidermis, are found in greater or less amount over the entire body, with the exception of the palms of the hands, the soles of the feet, the vermilion border of the lips, the glans penis, the labia minora, and inner surface of the labia majora. Over the majority of the surface they are short, rather colorless, having the character of the embryonic hairs, and hence are termed the lanugo hairs; but on the head, the eyebrows and the eyelids, in the axillæ, on the pubes, and in the male sex on the cheek and upper lip, they attain a much higher grade of development.

The hairs which are present upon the scalp, eyebrows, and eyelids become gradually more marked, thicker, and longer after birth, but at the age of puberty the hairs on the pubes and in the axilla, and the beard in the male, begin to develop and to increase rapidly. Hair also is found around the anus in the male. It is not unusual to see, in certain races, that in women, as they approach and pass the climacteric, a stronger growth of hair appears on the upper lip and face.

The hairs, both the lanugo and the fully developed ones, are for the most part placed obliquely in the skin and are situated in follicles termed the hair-follicles. These latter are sometimes short, the papilla lying high up, or, again, of considerable length, and deep down in the subcutaneous connective tissue. The portion of the hair situated in the follicle is the root, that above the level of the skin, the shaft. At the lower extremity of the root there is a whitish, soft, bulbous enlargement, the hair-bulb, which has a concave end that fits upon the conical vascular eminence already mentioned as being the hair-papilla.

The hair-follicle itself may be divided into three parts, according to its form. From its upper extremity, where it opens out upon the surface of the skin, it descends, shaped like a funnel, as far down as the opening of the duct of the sebaceous gland. It then becomes narrowed for a short distance, but broadens again near the papilla to receive the hair-bulb.

The hair-shaft varies considerably in shape, being in some cases round, in others much flattened, or again angular.

On cross-section the hairs are either round, or oval, or triangular, or square, having convex or concave sides. The angular and flattened hairs are found in those localities where the hair is curly, the round ones where it is smooth.

At its free external end the hair is pointed when in its natural state, but owing to the fact that it is continually subjected to mechanical influences, such as rubbing, etc., it is usually found to have a more or less rounded extremity.

Histology of the Hair and of its Follicle.—Hair-follicle. The hair-follicle is represented by a sac-shaped cavity composed of connective tissue. At its lower end, which is more or less deeply situated in the cutis, an eminence is seen, analogous to the papillæ in the upper portion of the corium, which is known as the hair-papilla. This body, upon which the concave extremity of the hair-root is accurately fitted, is oval in shape, and at its base is a distinctly marked constriction—the neck of the papilla. It is composed of connective tissue, similar to that of the cutis, of which it is a part, and contains blood-vessels.

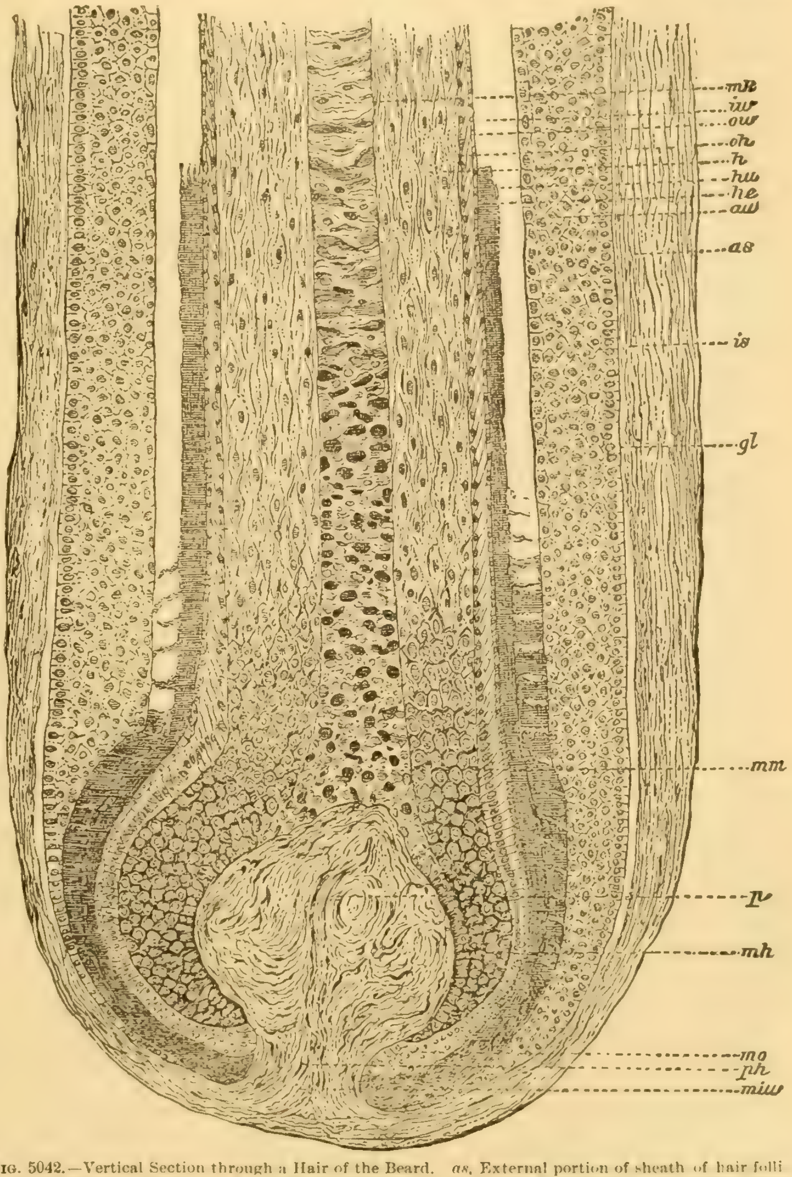

FIG. 5042.—Vertical Section through a Hair of the Beard. *as*, External portion of sheath of hair follicle; *is*, internal portion; *gl*, homogeneous membrane; *aw*, external root sheath; *iw*, internal root sheath; *he*, Henle's layer; *hu*, Huxley's layer; *ow*, cuticula of root sheath, *oh*, cuticula of hair; *h*, cortex of hair; *mk*, medulla; *p*, papilla; *miw*, *mo*, *mh*, *mm*, matrices of *iw*, *ow* and *oh*, *h*, and *mk*; *ph*, neck of papilla. (Ziemssen.)

The hair-follicle envelops the lower two-thirds of the hair and of its sheaths, but above the openings of the ducts of the sebaceous follicles it is not demonstrable as a separate formation, becoming lost in the tissue composing the papillary body. It consists of three coats. The most external of these is a portion of the cutis proper, and is composed of connective-tissue fibres, which are closely bound together, and run longitudinally in the axis of the hair, and is quite rich in connective-tissue cells. In it are distributed the blood-vessels and nerves supplied to the hair. The next innermost coat is composed of similar elements as are found in the most external, but they are arranged, however, in a circular manner running around the hair follicle. There are many nuclei found in this coat, the long axes of which are directed parallel with the course of the fibres, and they resemble very strongly the nuclei seen in unstriped muscles; but this resemblance is in all probability due to the tension to which the fibres are subjected.

The innermost of the coats of the hair follicle is a hyaline basement membrane, which has a glassy, transparent appearance. It is in immediate contact with the cylindrical layer of epithelial cells belonging to the external root-sheath of the hair. It is not always demonstrable, varying greatly in thickness, and is most clearly marked in the lower third of strongly developed hairs. In the lanugo hairs the connective-tissue envelope of the hair is absent, the root-sheaths being derived from the epidermis forming the hair follicle.

The Hair-sheaths.—The root of the hair proper is in the greater portion of its extent covered by an envelope, which consists of several layers of cells very adherent to it. It constitutes the inner root-sheath of the hair, and lies in contact with the external root-sheath, by which it is separated from the connective-tissue envelope of the hair follicle.

The Hair Proper.—When a fully developed hair is examined under the microscope, it can be seen that it is composed of three tissues, which differ from each other in appearance. These three portions are termed the cuticula, the cortex, and the medulla. Each of these can be easily recognized in the shaft of the hair, but not so readily at the bulb. Still, if the hair is treated with picrocarmin, the cuticula can be traced here, and it can be seen that it starts from the neck of the hair papilla (Unna). By the same method, it is also found that the cortex develops from the lateral portions of the papilla, and the medulla from the apex.

The Cortex.—The most voluminous portion of the shaft of the hair is constituted by the cortex, a transparent fibrillar mass of varying color. In it are seen dark spots and longitudinal streaks, which are situated between the horny elements of the hair, and are caused by the presence of air. Pigment granules are also present in greater or lesser quantities.

When the hair is treated with sulphuric acid the cortex breaks up into the fibres of which it is composed, and, if the action of the acid has been long continued, it may even separate into long, narrow, spindle-shaped plates. In the centres of these latter an indistinct linear figure is oftentimes traceable. It represents the remains of the nucleus of the cell from which the plate was derived.

The development of the hair from cells is very distinct as seen at the papilla. The portion of the hair in immediate contact with this body is hollowed out or concave in shape, and it is composed of a row of cylindrical epithelial cells entirely similar to those forming the basic layer of the epidermis. This layer of cells is termed the matrix of the hair, and it is upon it that the growth of the hair depends. Starting from this point it can also be seen how the cells and their nuclei grow longer, become finely fibrillated and granular, and finally, when entirely horny, appear as small plates. These successive changes should be studied on hairs which are little pigmented, for in them they can be seen much more easily than when the opposite is the case. The cells of which the cortex of the hair root is formed have been found by Waldeyer to be composed of small fibres. Each cell is united to the contiguous ones by short spines, in a manner analogous to the cells composing the epidermis.

The pigment which gives the hair its various shades of color is an important constituent of the cortex. It varies greatly in quantity, and in proportion to its abundance or comparative absence the hair is dark or light in color. It occurs both in a diffuse form and also in granules. The elements of the cortex are diffusely pigmented by the former, but the pigment granules are distributed here and there, and are situated in and between the cells composing the cortex (Waldeyer). This deposition of the pigment granules in the cells is most clearly seen in the root of the hair. The source of the pigment is not yet fully established, though Riehl, in his investigations has thrown some light on the subject. He found in the tissue of the papilla of the hair irregular-shaped, branched cells, the protoplasm of which contained a considerable amount of pigment. They were present as far up as the matrix of the hair, between the cells of which they sent long prolongations, and they could also be traced higher up as fine intercellular pigment deposits. Riehl also observed that the cells of this portion of the hair root, which were not yet horny, contained granules of pigment around their nuclei, and also that the cells of the matrix were quite closely connected with the prolongations of the wandering pigment cells of the hair papilla, from which their protoplasm took up pigment granules. In regard to the source of these granules, Riehl argued that, inasmuch as wandering pigment cells were regularly met with in the papilla of the hair and following the course of the blood-vessels, the blood must be the source of the pigment, and this latter must be carried by the cells to the hair.

The Medulla.—The medulla is situated in the axis of the hair throughout almost its entire length, but it narrows and terminates at some distance from the free end. It is marked in the stronger hairs, but is usually absent in the lanugo hairs, and often also in those of the scalp. The presence of the medulla is shown by a more or less broad, longitudinal band of a dark color, which is due to the air situated between its composing elements. These latter are cells which are shrunken into irregular shapes, possess no nuclei, and are furnished with spines and prongs (Waldeyer).

At the base of the hair, the medulla differs very slightly from the cortex. Over the apex of the papilla and above the cylindrical cells situated there, and which represent the matrix of the medulla, large nucleated cells are seen, and in their protoplasm are large drops of keratohyalin. In proportion as the shaft is ascended, these cells become shrunken, harder, lose their nuclei, and the keratohyalin disappears. They are bound together by means of the spines and prongs on their surface, between which are left spaces—intercellular spaces. Below the external surface these spaces serve as channels through which nourishment is furnished to the young cells of the medulla, but where the hair is exposed to the external atmosphere this fluid evaporates, and the spaces become filled with air.

The Cuticula.—The hair is also furnished with a cuticula which surrounds the majority of that portion of the hair which lies in the follicle. It is formed by a layer of horny plates, arranged like tiles on a roof, and they are closely bound together. The cuticula originates from the neck of the papilla of the hair between the matrix of the cortex and that of the inner root-sheath. At this point it consists of several rows of cylindrical nucleated cells, which divide soon after leaving the matrix into two layers. One of these goes to form the cuticula of the hair, the other the cuticula of the inner root-sheath. The cells of the former are, at the neck of the hair papilla, directed perpendicularly to the circumference of the hair, but gradually become more and more inclined toward it. At the upper portion of the hair-follicle the cuticula is no longer distinguishable, and becomes a constituent portion of the cortex. At the matrix the cells are epithelial in character, but they become transformed into solid transparent horn plates without nuclei.

The Root-sheaths.—The hair root is further enveloped by two coats—the root-sheaths—which are closely adherent to it. They are known, individually, as the inner and the outer root-sheath. The former is immediately around, and in contact with, the hair, and ends within the hair follicle; the latter, more external, passes up to the orifice of the follicle, where it becomes continuous with the spiny layer of the epidermis.

The Inner Root-sheath.—The inner root-sheath is composed of three layers—the cuticula, the one nearest the hair, Henle's layer, the most external, and between these two Huxley's layer.

The cuticula of the inner root-sheath arises from the same matrix at the neck of the hair papilla as the cuticula of the hair. The cells composing it are so arranged that their long axes are parallel to the circumference of the hair, that is, in an opposite direction to those forming the cuticula of the cortex. They undergo transformation in a manner entirely analogous to the one which has been already described for the cuticula of the cortex. The cuticula of the inner root-sheath is lost sight of within the follicle, becoming a part of the sheath.

The Layers of Huxley and of Henle.—The portion of the inner root-sheath which is situated between the cuticula just described and the external root-sheath is composed of the two layers known as those of Huxley and of Henle. They also take their origin from the neck of the papilla, and at that point appear as a layer of three or more cylindrical epithelial cells. Drops of keratohyalin, however, appear very soon in these cells, and this substance increases rapidly in quantity. The change in their appearance due to the presence of the keratohyalin is very marked on a level with the apex of the papilla, and the cells are seen here to have attained a much larger size. The cells forming the layer of Henle—the most external—contain, however, a greater amount of keratohyalin, and undergo hornification much more rapidly than they do in the layer of Huxley. Consequently, Henle's layer is found represented by horny, polygonal, non-nucleated elements at a much lower level than Huxley's layer. This latter, the inner portion of the inner root-sheath of the hair, is composed at the papilla of cells which contain a smaller amount of keratohyalin. Keratofication in them is not so rapid as in the cells of Henle's layer, the nuclei do not disappear so early, and the complete transformation of the elements of Huxley's layer into horny masses occurs at a higher level than is seen in the former one. The inner root-sheath ends in the hair-follicle.

The External Root-sheath.—In describing the embryology of the hair, it was stated that the first changes observed consisted in a proliferation and prolongation downward into the cutis of a portion of the cells forming the stratum spinosum of the epidermis. The further steps which occurred in the evolution of the hair, and which took place in the central portion alone of this prolongation, it has also been seen, resulted in the formation of the shaft of the hair, but the remaining portion also serves an important purpose. It represents the external root-sheath, or envelope, of the hair, and is separated by it from the connective tissue composing the follicle.

The outer root-sheath is not uniform throughout its entire extent, but is lined on the surface next to the hair-shaft, and as far down as the opening of the duct of the sebaceous gland, by the stratum corneum and stratum granulosum. From here to the level of the hair-papilla the stratum spinosum descends in its entirety, but then narrows, and at the neck of the papilla is reduced to a layer of two or three cylindrical cells. It lies at this point in close contact with the cells from which the inner root-sheath is formed.

The appendages of the hairs are the sebaceous glands, and bundles of unstriped muscular fibres are also attached to them. They have been, however, already described, and do not demand any further notice.

George T. Elliot.

SPINA BIFIDA. *Definition.*—Spina bifida is the name applied to a congenital hernia of the membranes of the spinal cord through a cleft in the walls of the spinal canal. It commonly presents itself as a rounded fluctuating tumor of varying size at the junction of the lumbar and sacral regions of the vertebral column.

Frequency.—It is by no means a very uncommon affection, as shown by the statistics of Demme[1] and Chaussier; the former found 57 cases in 36,148 births, while the latter recorded 22 cases in 22,293 births at the Paris Maternité. In 1882 there died from spina bifida in England and Wales, according to the report of the Registrar-General, 647 children (296 males and 351 females), 89 deaths occurring in London alone. Spina bifida is always congenital, and belongs to the class of congenital malformations due to an arrest of development; but three well-authenticated cases are reported where the tumor seems to have appeared some time after birth.[2] Its etiology is no more clear than that of the kindred affections, harelip, cleft palate, persistent branchial clefts, and the like. Heredity undoubtedly plays a certain part, cases being recorded where several members of the same family have been affected.

Cause.—It is, however, easy to see in what way it comes about that there may be a defect in the laminæ of the vertebræ. The vertebral canal is formed in the embryo by a furrow in the mesoblast, the sides of which furrow grow up and join over the top, enclosing, of course, a part of the epiblast. From the proto-vertebral plate grow up two processes, one on each side, which arch over the future spinal canal, and, joining in the median line above, become cartilaginous and finally ossify by three centres, one for the body and one for each lamina. A defect in this joining or ossification would cause a cleft in the median line of the vertebral canal on the posterior surface. The primary defect, then, is an absence of the laminæ and spinal processes. Sometimes, though rarely, this condition extends through the length of the vertebral column,[3] and then life is impossible. Sometimes it is confined to a defect in one vertebra, but commonly it includes two or three vertebræ, causing an oval tumor whose longest axis is in the line of the spinal column. Bryant has reported a case where the defective ossification was in the bodies of the vertebræ, and the tumor consequently occupied an anterior position.[4]

Associated Deformities.—It is often associated with talipes equinovarus, hydrocephalus, and the like. In some 300 children the following complications were noted, though they are probably of more frequent occurrence than the table would seem to indicate.

	Clinical Society table.	Demme's table.
Paralysis	53	Not stated
Talipes	42	13
Hydrocephalus	30	17
Idiocy	2	Not stated
Cretinism	1	"
Curvature of the spine	2	"
Absence of the cerebellum	1	"
Harelip and cleft palate	1	3
Imperforate anus, etc	2	1

Location.—Its location is, in about six-sevenths of all cases, sacral and lumbar, for here the vertebral laminæ are last solidified. Of the 236 cases analyzed by the London Clinical Society, 194 were lumbar or sacral, 8 dorso-lumbar, 14 dorsal, 13 cervical or cervico-dorsal, and 7 coccygeal. In general, the mid-dorsal region is the least likely to be affected.[5]

Formation of the Tumor.—There have always been two theories as to the primary cause of the deformity—one, that an early dropsy of the membranes of the spinal cord takes place and prevents the ossification of the laminæ; the other, that defective ossification of the laminæ is the sole cause; and this latter, the Dareste-Koch theory, meets to-day with acceptance to the exclusion of the other. It is chiefly the investigations of Recklinghausen[6] that have brought this about, and, in exact language, the cause of the deformity is found to be a local aplasia of the mesoblast, the cord remaining in the stage of the medullary plate. The investigation of thirty-one specimens established the facts (and the conclusion rests on such facts as these) that: 1, In myelo-meningocele the external wall of the sac consists not of dura mater but of pia mater turned inside out; and, 2, the remnant of the cord often corresponds with the persistence of the medullary groove in being itself bifid. And in the whole series no warrant was found for the old theory that the cause lay in dropsy of the membranes; also, when the latter occurred it was seen to be a result of the defective development instead of its cause.

Physical Characters.—Spina bifida presents itself as a tumor strictly in the median line, varying in size from that of a walnut to that of an infant's head (Fig. 5042). It is fluctuating and ordinarily partly reducible, and it can be seen to communicate with the spinal canal, usually by the following signs. The tumor becomes tense when the child cries, and it becomes less tense when the pelvis is raised and the fluid allowed to run into the vertebral canal. When hydrocephalus is also present, pressure on the sac causes the anterior fontanelle to bulge, and pressure on the fontanelle makes the sac tense; and ordinarily the opening in the vertebral canal can be felt by drawing the tumor to one side and making rather deep pressure with the fingers, and at the same time the sac will be felt adherent around the edges of the opening.

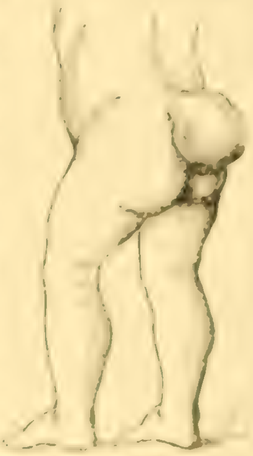

FIG. 5042.—Spina Bifida. (Treves.)

The tumors are either sessile or pedunculated; in the latter case the opening into the canal is smaller and communication less free, and an inflammation of the neck of the sac, and obliteration of the communication, is far more likely to happen. A case is reported where there was a pedicle a foot in length.[1]

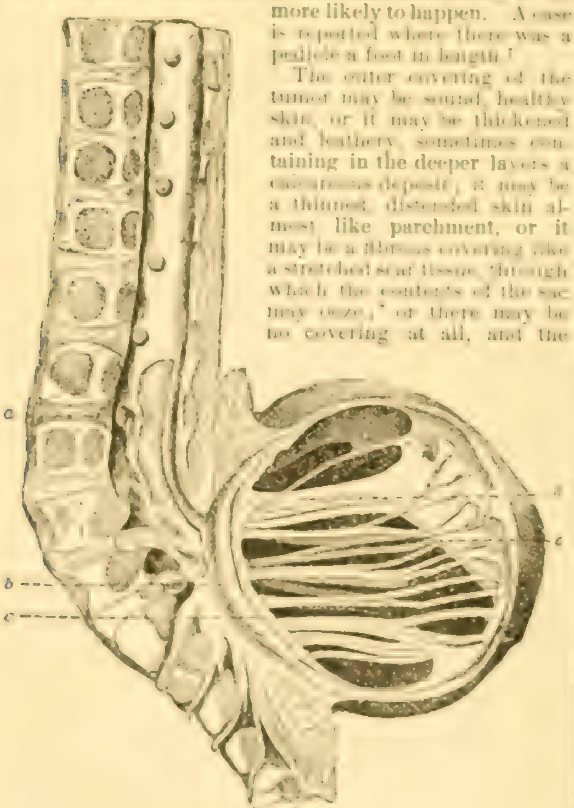

FIG. 5043.—Diagram of the Parts involved in a Lumbo-sacral Spina Bifida [illegible]

The outer covering of the tumor may be sound, healthy skin, or it may be thickened and leathery, sometimes containing in the deeper layers a calcareous deposit; it may be a thinned, distended skin almost like parchment, or it may be a fibrous covering like a stretched scar tissue, through which the contents of the sac may ooze;[2] or there may be no covering at all, and the bluish-red dura mater is seen protruding without protection. Whatever the character of the sac, its tendency is to ulcerate under the continued and increasing pressure, and herein lies the danger. Sudden evacuation of the contents of the tumor, and the consequent communication with the air, is very apt to lead to immediate death from violent convulsions, or an extensive destructive meningitis and myelitis.

Pathological Varieties.—Under the skin and adherent to it is found the sac, the walls of which are formed by the membranes of the spinal canal. Three varieties of little practical importance are made according to the contents of this sac: (1) When the membranes alone protrude it is spinal meningocele; (2) when the membranes, together with the spinal cord and nerves, protrude, it is meningo-myelocele (Fig. 5044). In both these cases the collection of fluid is between the cord and membranes (hydrorrhachis externa). When, however, the collection of fluid is in the central canal of the spinal cord (hydrorrhachis interna), the inner lining of the sac cavity is formed by the thinned and spread-out substance of the cord, and the condition (3) is known as syringo-myelocele. These varieties are the ones adopted in the classical report of the London Clinical Society already referred to.

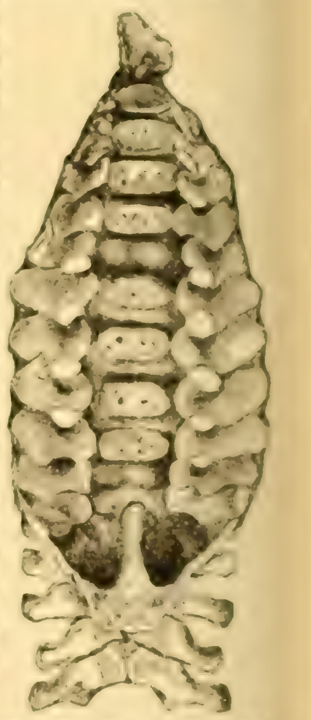

FIG. 5045.—Part of a Spinal Column [illegible] (The Clinical Society's Transactions, vol. xviii.)

The condition most commonly found is the second one, where some of the nerves, and probably part of the cord, enter into the contents of the sac; and on the point whether or no the cord is present in the sac must depend the advisability of active treatment. Follin and Duplay found the cord or nerves forming part of the sac in five per cent. of all cases; and Prescott Hewett, in twenty, found only one free from nerve structures in the sac.[3] The Clinical Society's Committee examined one hundred and twenty-five specimens, leaving out cases of syringo-myelocele, and found that the cord entered the sac in seventy-nine, or 63.2 per cent. It may be only a few nerves running irregularly along the inner surface, or it may be a complete cauda equina that one finds; sometimes the cord runs into the sac and again returns to the spinal canal lower down; and, lastly, one finds the condition described above where the atrophied cord is spread out over the inner surface, and, when the cord is consequently found fatal. In general the nerve-structures are adherent to the sac in the posterior median line, and it is said that a depression in the external surface of the tumor signifies the presence of the spinal cord in the sac; but it is no reliable test. As a rule the larger the opening in the vertebral canal the more likelihood there is that the cord is present in the sac.[4] Certain symptoms indicate the presence of the cord in the tumor. If tapping or manipulation of the sac cause convulsions or nervous symptoms, if the tumor increases in size, and with the increase in size convulsions begin, and if paralysis of the legs and sphincters is present, the chances are very strong that the cord is in the sac.

The fluid contained in the tumor is merely cerebro-spinal fluid, numerous analyses of which have been made.[11]

Sometimes one finds in the sac small masses of connective tissue and fat, but these are not common. Cases have been reported in which two or more sacs were present,[12] but these, too, are mere pathological curiosities.

Symptoms.—Children affected with spina bifida are often the subjects of other malformations, as, for example, in a case lately reported by Sutton, in addition to spina bifida there were also present lateral curvature, talipes equinus, atresia ani, imperforate pharynx, and only one kidney.[13] As a rule, the children are feeble and badly nourished. Associated very often with the tumor (and probably always when the fluid distends the internal canal of the cord) are paralyses, more or less complete, of the sphincter and muscles of the lower limbs, due to the implication of the nerves in the sac. Paralysis of motion predominates in the limbs, but complete paralysis of sensation is often associated with it. The distribution of the paralysis may rarely be unilateral.[14]

Convulsions occur with greater or less frequency, and are apt to be excited by pressure on the tumor.

Prognosis.—The affection is one of great gravity, and its course when untreated is of the greatest importance in regard to the advisability of treatment. Speaking generally, the tendency of these tumors is to increase in size from birth, and the distention causes the skin or other covering to ulcerate and thus the contents of the tumor are evacuated. This means death in most cases, but sometimes a spontaneous cure results; even a fistula may remain, and the child may live. A spontaneous cure is, of course, most apt to happen in cases where the tumor is pedunculated and the opening into the spinal canal is small.

Still more rarely there are cases where the tumor, after being stationary or increasing in size for some time, undergoes a retrograde change and shrivels without bursting; but such cases are uncommon.[15]

The general tendency in untreated cases is then to a fatal issue. Demme observed 57 cases, and in 32 no operation was done, and at the end of two years not one was alive. The Clinical Society collected 60 cases where no operative treatment was attempted, and found 14 cases where a spontaneous cure is said to have resulted; but the committee says: "These figures do not, however, represent the real mortality of the deformity when allowed to run its natural course," because only favorable cases are put on record in the journals.

Patients, however, occasionally reach adult life with the spina bifida still persisting. The Clinical Society recorded six patients between twenty-five and forty-three years of age; Behrend reported one case, fifty years of age, who still had the tumor unchanged;[16] and Callender one seventy-four years of age. The prognosis after the various operations will be considered in speaking of the treatment.

Diagnosis.—The diagnosis of spina bifida rarely presents any difficulty. The presence of a fluctuating, elastic, rounded tumor communicating with the vertebral canal by a defect in the posterior surface of the vertebral column is perfectly characteristic. Certain other congenital tumors, however, present a superficial resemblance to the affection under consideration.

1. False spina bifida is a term which has been applied loosely to all sorts of tumors in the lumbar and sacral regions, but, as Treves suggests, the term "should be applied to one tumor only, namely, to a spina bifida whose communication with the spinal membranes, and perhaps with the spinal canal itself, has been cut off." Such a tumor will be found in the ordinary location for spina bifida, strictly in the median line; it will not communicate with the spinal canal, and it will almost always be pedunculated, and very likely an examination of the history of the case will show that at one time it presented all the symptoms of a true spina bifida.

Certain congenital cystic tumors may be confused with false spina bifida, but the diagnosis between them is of no practical value, as the treatment is the same. These cystic tumors are generally multilocular, and therefore irregular in outline, not pedunculated, and often containing solid masses; these points will ordinarily establish the diagnosis.

Other congenital tumors of the sacro-coccygeal region need only to be named: 1, attached fœtuses,[17] sometimes with the remains in a cystic cavity or hanging from the back; 2, caudal excrescences, either supplementary coccygeal vertebræ or fibro-cellular masses; 3, congenital tumors, either cystic, as described above, or fatty, or fibrous. They present no difficulty in diagnosis.

Treatment.—The great obstacle to the successful treatment of spina bifida is the very frequent presence of the nerves and spinal cord in the tumor. The rarity of spontaneous cure, on the other hand, makes one inclined to adopt operative measures if they offer any likelihood of relief. In general, small tumors with pedicles, which communicate with the spinal canal by a small opening, are the most favorable ones for operations, and also, as we have seen, the ones most likely to undergo spontaneous cure.

Certain cases, all admit, should be let alone, especially those where hydrocephalus, marasmus, or intercurrent diseases are present. Certain other cases are not likely to be successfully treated, even by the mildest and safest operative procedures; these are cases where there is reason to suspect that the cord is present in the sac, such belief being based upon a depression in the skin, the size of the tumor and its communication with the canal, or the presence of paralysis, club-foot, or the other symptoms noted above. Very early operation is now discountenanced by nearly everyone; unless some very strong indication is present, treatment should be deferred until the child is two or three months of age. The palliative method should be adopted for a while, and if the case is kept under observation, such a course is attended by no risk. It can then be easily determined, in the course of a few weeks or months, what the course of the tumor will be. If it increases, operation must be considered; if it remains stationary, it will be safe to wait longer; and if it should diminish in size, nothing should be done. Certain means of protection are necessary to support the mass and prevent the clothes from chafing the skin, and at the same time to exercise a mild compression. The best dressing consists of cotton-wool, smeared with vaseline, lightly bandaged on. Another and much recommended application is painting the whole tumor with collodion, or collodion and castor-oil; but this tends to irritate the skin, and is especially unsuitable where a tendency to ulceration is present. When it is decided to continue the expectant treatment over a long period of time, or indefinitely, an accurately moulded leather or gutta-percha cap should be worn over the tumor, held in place by a belt around the waist.

If, however, the tumor increases in size, or, for any other reason, operation seems advisable, one of three operative proceedings has to be chosen: 1, puncture; 2, injection; 3, extirpation of the tumor.

1. *Puncture* has deservedly gone out of favor with the introduction of more intelligent methods. The evacuation of the entire contents of the sac at once, by this method, is, of course, risky in the extreme and not to be thought of. The only rational application would be a puncture to one side of the median line, made under every possible antiseptic precaution, and the evacuation of small amounts of fluid at different times. The Clinical Society's committee found on record 46 cases treated in this way; 30 of these died, 12 recovered, 2 were not relieved, and 2 were unaccounted for. Fourteen cases died of meningitis, and 8 of "convulsions" (probably meningitis also). The committee concluded that "this method of treatment is an imitation of that local change in the tumor (rupture) which most often ends fatally, and its disastrous results are, therefore, by no means surprising. . . . It should not be undertaken even as a palliative measure."

2. *Injection.*—It is generally accepted that the presence of the cord in the sac, when it can be definitely established, though not a positive contra-indication to

treatment by injection renders its utility somewhat questionable and adds to its danger. Paralysis has resulted directly from the employment of an iodine injection, and death has come on in half an hour after careful injection of Morton's solution in an apparently suitable case, so that the proceeding cannot be considered free from risk. Velpeau used a similar method, withdrawing the fluid and substituting iodinated water, just as one would in a hydrocele. Brainard, of Chicago, withdrew six ounces from the tumor, then injected half an ounce of a solution of iodine and iodide of potassium (5 grains and 15 grains to the ounce of water), let that run out after a moment, and then put back two ounces of the cerebro-spinal fluid originally withdrawn, and sealed the puncture. Morton, however, in a slight modification of the method, has produced the most successful injection of all. The advantage of his method seems to lie in the glycerine, which serves as a vehicle for the iodine, and which by its great specific gravity sinks to the bottom of the sac when the child lies on its back, and so does not enter the spinal canal as other injections probably do. A solution is used containing ten grains of iodine and thirty of iodide of potassium in an ounce of glycerine. A drachm or so of the fluid contents of the sac is withdrawn in order that the addition of the injection may not make the sac too tense, and then half a drachm or a drachm of the iodo-glycerine solution is slowly injected and the puncture sealed with collodion. A little inflammation results in all cases, but it soon subsides, and after from ten to fourteen days the proceeding should be repeated. The puncture should always be made to one side of the median line and obliquely through the sound skin, and a hypodermic syringe best serves the purpose. If a good result follows the use of this method the sac shrinks, and the process imitates the most favorable method of natural cure.

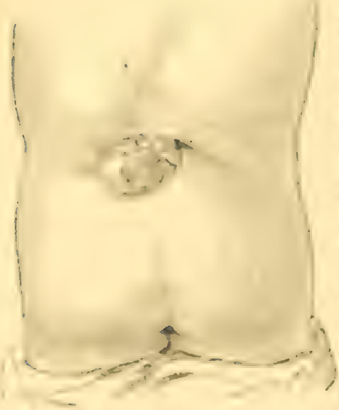

FIG. [illegible].—Spina Bifida. Appearance of the Tumor after [illegible]

So great was the reported success of Morton's method that the London Clinical Society appointed a committee to investigate the real value of that means of treatment, and they reported 71 cases—35 recovered, 27 died, 5 were unrelieved, and 4 were relieved. Meningitis caused only 7 of the deaths, and convulsions only 2, while 5 died of shock. A number of these cases were quite hopeless—cases in which other methods of treatment would not have been entertained. Morton's own report of the operation is still more favorable. In the edition of his book in 1887, he reports 65 cases treated, with 55 recoveries and 10 deaths. In his own experience he has operated 29 times, with 6 deaths. These percentages of recovery of course show a very different state of affairs from what one gets from any other treatment. The method is daily coming into greater use, and except for very unusual cases is the proceeding to be recommended. Successful cases are constantly being reported in the journals.

3. *Extirpation of the Tumor.*—In considering operative procedures for the removal of the tumor one fact is self-evident, that such operations are only applicable in cases where it is definitely determined that the cord is not present in the sac, and that, of course, restricts the field very much. Ligature and excision are the two methods. Ligature is best done by gradual compression between splints to excite adhesive inflammation at the neck of the sac, and a number of successes by this method are found-ed. Mosher cured three cases out of six with an elastic ligature. Sometimes a ligature is put around and drawn tight, or the mass is crushed off with the écraseur, and then death results with certainty if the cord is present.

Excision is practised in all sorts of ways, and the literature is full of modifications and new methods of it. The fact remains that when the sac is free from cord and large nerves, excision is the simplest of operations, and when the cord is present no operative skill will be likely to avert a fatal result (Lebrecht). One author proposes to open the sac and see if the cord is present, and if so to abandon further treatment. Mayo Robson recently has reported two successes out of four cases operated on by simple excision. He advises rather a wide application of the method, and would even cut out pieces of the sac between nerves, when they were present, and reduce the collapsed sac into the canal. A really useful modification of this operation has been recently proposed and has been successfully carried out, namely, fracturing the laminæ on both sides of the vertebral cleft and suturing them in the median line after the extirpation of the sac. Robson and Hayes, of Rochester, have brought about the same closure of the cleft by implanting a strip of periosteum from a rabbit. It is well to shut off communication with the vertebral canal by a ligature before opening the sac, as a sudden evacuation of the contents may produce serious results on the cerebrum and cord. A full account of the various useless modifications of excision can be found in Holmes' "Surgery."

But excision is not without its successes. Of 23 cases 16 recovered and 7 died (but the cases were probably very carefully selected), 5 of them from meningitis. Commenting on these results the committee says: "We are compelled to regard excision of the tumor as an inappropriate treatment of spina bifida."

In conclusion, it may not be inappropriate to call attention again to the fact that the cord is present in the sac in sixty to seventy per cent. of all cases. Having this fact in mind, the treatment of an average case would be summarized as follows: For the first months palliative measures alone should be used, in the hope that spontaneous shrinking may take place. If at the age of two months the tumor has increased in size, Morton's injection should be tried; if the tumor is stationary, it should be let alone for two months more. In either case, if Morton's injection fails and it seems reasonably sure that the cord is not present in the sac (and on this it all depends), a simple excision of the tumor should be done. If there is reason to suspect the presence of the cord in the sac, excision is, of course, out of the question, and the case must be left to itself.

Robert W. Lovett.

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[1] [illegible] Medicinischer Jahresbericht [illegible] 1882.

[2] Carr: Medical Times and Gazette, October 2, 1858, and [illegible], quoted by Morton, Spina Bifida, Philadelphia, 1887.

[3] Velpeau and Bérard: Traité de Path. externe.

[4] Brainard: Medical Gazette, 1858.

[5] [illegible], quoted by Parker, article in [illegible] of Practical Surgery. [illegible] Archiv f. Kinderheilkunde, Bd. [illegible], H. 6.

[6] Boston Medical and Surgical Journal, 1882, 436.

[7] [illegible] Arch. de Chir., [illegible] 272.

[8] London Medical Gazette, 1844, xxxiv.

[9] [illegible] p. 64.

[10] Morton: Spina Bifida, p. 27. London, 1887.

[11] Smith: Pathological Society's Transactions, 1869, xxvi., 11. Paget, quoted in [illegible] International Encyclopædia, vol. [illegible]

[12] Lancet, November 3, 1888.

[13] [illegible] 1889, 542.

[14] Medico-Chirurgical Transactions, vol. xl., p. 19. Transactions of the London Pathological Society, vol. xvi., p. 18.

[15] [illegible] f. Kinderheilkunde, xxxi.

[16] W. [illegible] und angeborene Geschwülste der Kreuzbeingegend. Leipzig, 1872.

[17] [illegible] 1888, 2d S. L., p. 619.

[18] [illegible], quoted by Ashhurst: Prin. and Pract. Surg., p. [illegible], Philadelphia, 1888.

[19] [illegible] Ther. [illegible]

[20] [illegible] Medicale, 1876.

[21] British Medical Journal, April 4, 1885.

SPINAL CORD. The spinal cord (myelon) is an imperfectly cylindrical column of nerve substance extending from the brain, which appears to be attached to it as an enlarged outgrowth, to a variable point in the spinal canal. In man this point is stated as lying between the altitude of the first and second lumbar vertebræ. In reality it does not terminate, it merely becomes attenuated here into the so-called *filum terminale*, a structure which has all the morphological features of the more voluminous region of the cord, though physiologically it plays no important part in the human organism.

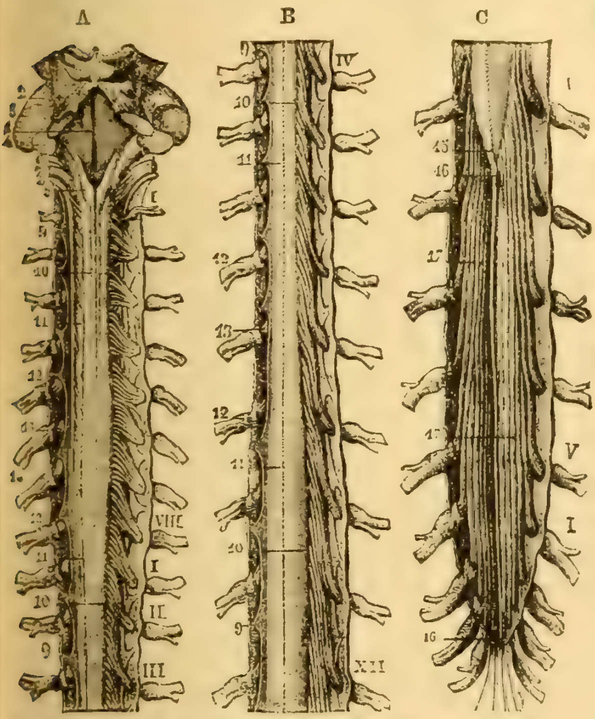

FIG. 5047.—The Cord seen from its Dorsal Face. (After Sappey.) A, The uppermost (cephalic) segment, including the cerebral attachment and extending to the origin of the third dorsal pair of nerves; B, the next following segment, including the origins of the remaining dorsal nerves and the beginning lumbar enlargement; C, the lowest (caudal) segment, including the end of the lumbar enlargement and filum terminale. The Roman numerals indicate the respective nerve-roots. At A, from I to VIII, the cervical; I to III, the upper dorsal. At B, the remaining dorsal from IV to XII. At C, the lumbar from I; V, the sacral from I to V; the lowest unnumbered are the coccygeal, and are not accurately represented in the figure. 1, Sulcus ventriculi quarti; 2, prepedunculus (processus e cerebelli ad cerebrum); 3, medipedunculus (processus ad pontem); 4. postpedunculus (restiform body, etc.); 5, clavæ or oblongata enlargement of column of Goll; 6, glossopharyngeal nerve; 7. vagus nerve; 8, spinal accessory nerve; 9, 9, 9, attachments of ligamentum denticulatum; 10, 10, 10, origins of dorsal (posterior or sensory spinal nerve-roots); 11, 11, 11, dorsal longitudinal septum (incorrectly termed the dorsal or posterior fissure); 12, 12, 12, spinal or intervertebral ganglia of the sensory roots; 13, 13, the sensory roots being divided on the left side, the motor (ventral or anterior) roots can be seen for a slight extent as they are about to join; 14, the division of a full spinal nerve into its ventral and dorsal peripheral branches; 15, conus medullaris; 16, filum (terminale); 17, 17, cauda equina.

The cord is essentially a segmental organ. In the typical vertebrate it may be regarded as made up of a series of nerve-centres, fused into a column; each centre corresponds to a somatic segment with which it is connected symmetrically by a pair of spinal nerves. In such a vertebrate, as well as in the embryos of higher vertebrata (see Embryology of the Brain, this HANDBOOK, Vol. I., p. 633), the spinal segment corresponds in its topographical situation with the somatic segment which its nerves supply, and these nerves take a direct transverse course, leaving the cord at right angles to traverse the intervertebral foramina and thus reach their somatic destination. But owing to the atrophy of the caudal segments of the body in higher animals, particularly in man, this topographical correspondence becomes lost. While both the vertebral column and the spinal cord continue growing in the fœtus and child, yet the growth-rate of the vertebral column is so much greater that the cord appears to shrink upward relatively to the surrounding bony channel.* Consequently, the spinal cord origin of the lower spinal nerves moves up far above the corresponding intervertebral foramina. From this it results that while the course of the upper cervical nerves is directly transverse, each succeeding nerve makes an angle with the cord, which becomes more and more acute (Fig. 5047, B), until in the most caudal segments the origins of the nerves almost attain parallelism with the cord (Fig. 5047, C). The roots of the lumbar and sacral nerves are thus compelled to travel a long distance within the spinal canal before they can make their exit, and as these roots are numerous, large, and run nearly parallel, they have been compared to the hairs of a horse's tail (cauda equina). The resemblance to that appendage is heightened by the mode of origin of the rootlets from the conus medullaris, which latter resembles the core of a horse's tail (Fig. 5047, B, 15, and 17, 17).

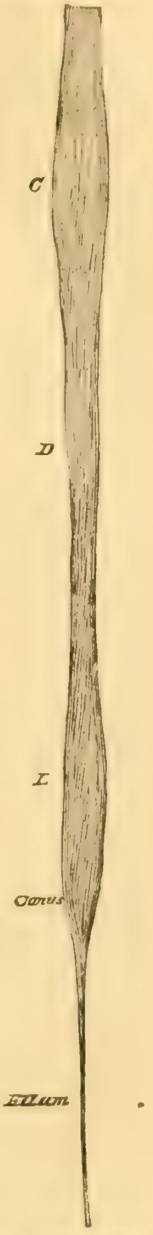

FIG. 5048.—Diagram after Measurements made by Author of Human Cord, to show Relative Dimensions of Various Parts. C, Cervical enlargement; D, dorsal region; L, lumbar enlargement.

The cephalic limit of the spinal cord is an arbitrary one, inasmuch as there is a complete continuity, both in structure and appearance, between the cephalic region of the cord and the oblongata (see description of Myelo-cerebral Transition). The boundary is assumed to correspond to the plane of the foramen magnum, and passes through the cord immediately cephalad of the first cervical pair. From this point to the caudal end of the conus, and excluding the filum, the length of the cord is between forty-one and forty-five centimetres, varying with the size and sex of the individual; for notwithstanding its greater relative length in the female, it is in that sex absolutely shorter than in the male. The weight of the cord is between twenty-seven and thirty-two grammes.

On the whole the cord, as stated, may be compared to a cylinder, but this cylinder is not a mathematical cylinder anywhere, and in some regions, as in the cervical, shows considerable departure from even an approximate cylindrical outline in cross-section. Aside from this there are considerable variations in dimensions. The chief of these are due to the two enlargements. Of these one corresponds to the origins of the four lower cervical and the first dorsal nerve, and is known as the cervical enlargement. The other corresponds to the origins of the lumbar and sacral nerves, and is named the lumbosacral enlargement. These names, therefore, do not indicate topographical situations, but physiological relations: the cervical enlargement corresponding to the origin of the arm-nerves, the lumbo-sacral enlargement to that of the leg-nerves. The cervical enlargement is characterized by a greater width than depth, the lumbo-sacral is more equal in its caudo-ventral and lateral diameters. A glance at Fig.

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* In the new-born child the length of the cord is to that of the vertebral column as 855 to 1,000; in adults it is as 750 to 1,000. There is some individual variation. the cord of the female is slightly longer than that of the male, the difference amounting in extreme cases to half the altitude of a lumbar vertebral body. The flexures which the cord makes in accommodating itself to the bent course of the spinal canal are impressed upon its structure; in other words, the cord itself, even when removed from the spinal canal, shows a marked cervical flexure (Flesch).

tion will show these relations better than any description in words. The outline of the upper part of the cervical region is nearly circular; through the greater increase of the transverse diameter this becomes a transverse ovoid in the cervical enlargement (C7, C8), to again become nearly circular in the dorsal region; while in the lumbosacral enlargement a rounded quadrilateral is characteristic, again succeeded in the conus and filum by a more regularly circular shape.

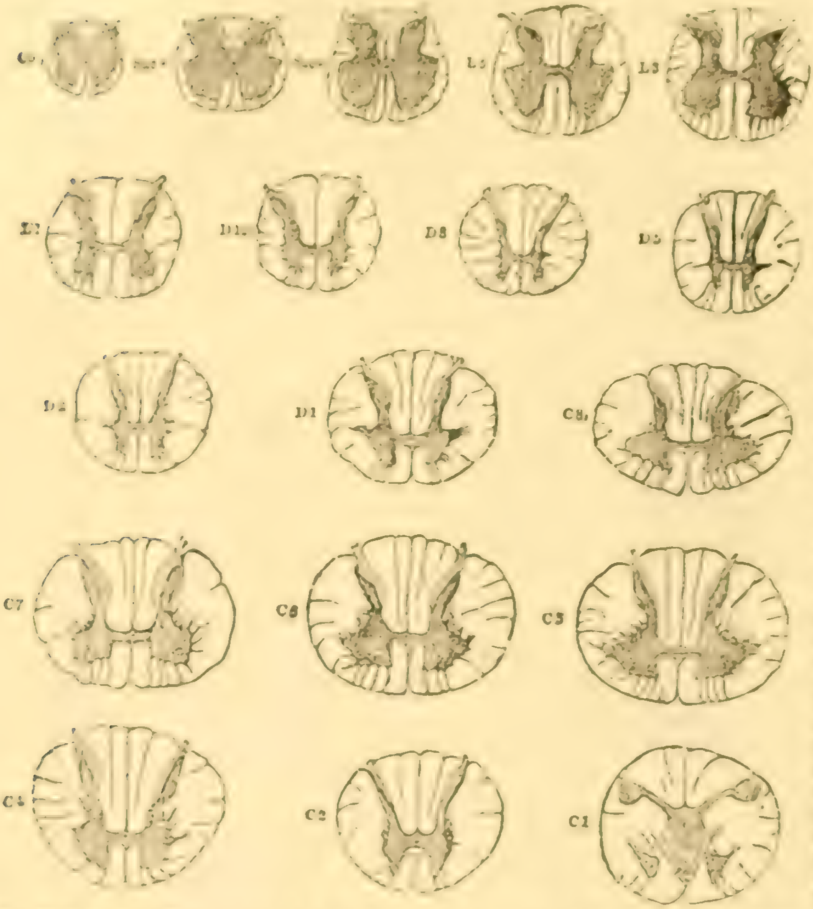

Fig. [illegible].—Sections Transverse of the Cord, taken at Successive Levels and beginning at the Lower Part of the Conus Terminalis. Twice the natural size. (After W. R. Gowers.) [illegible]

The cord, like the brain, possesses three investments: one nutritive, the pia, which immediately adjoins, and is connected with, its proper substance; one protective, and adjoining the bony canal, the dura; and a third, delicate intermediate structure, the arachnoidea, which fills out the extensive space intervening between dura and pia. The vessels of the pia give the ventral and dorsal faces of the cord their characteristic color and markings. In young healthy persons the color is between a clear white and a rosy tint; in older ones, a yellowish or greyish-yellowish discoloration is often observed, without indicating any ascertainable pathological state. As in the cerebral pia, opaque and punctate pigmentation is sometimes observed in the upper cervical region, particularly in the negro.

As the appendages of the cord are homologous with those of the brain, and identical with the corresponding dura cerebralis, arachnoidea cerebralis, and pia cerebralis in the main structural respects, it is the points of difference alone that need detain us here. The dura mater *spinalis* is thinner than the cerebral dura. This is to be accounted for by the fact that the cerebral dura represents at once the fibrous envelope of the neuraxis and the periosteum of the skull; at the foramen magnum its inner lamellæ alone are continued into the spinal dura mater; the outer become continuous with the periosteum of the spinal canal.* The spinal dura, therefore, corresponds only to the innermost or neuro-visceral part of the cerebral dura. This explains why the spinal dura, unlike the cerebral dura, is a free sac, independent of the lining of the surrounding bony canal. It constitutes a cylindrical bag, extending from the attachment at the foramen magnum free through the spinal canal far below the conus and fusing its walls, so as to lose its lumen at the level of the second or third sacral vertebra.† After losing its lumen the spinal dura continues on, fusing with the atrophied caudal prolongations of the arachnoid and pia, to become distinctly lost in the coccygeal periosteum. The connective-tissue band thus formed, superficially considered, bears the same relation to the dural sac which the filum (terminale) bears to the cord proper.‡

The *spinal arachnoid* is a delicate tissue without proper vessels, which presents an outer, smooth, membrane-like face to the dura, while internally it is continued and fused with the pia by means of a delicate cellular tissue, which may be regarded as the seat of a physiological dropsy. Its large meshes are filled with a clear fluid, the liquor cerebrospinalis. The outer smooth portion, which is near the dura, is sometimes discriminated as arachnoidea propria, the meshes between it and the pia as the *subarachnoid tissue*. The slit-like space, analogous to the spaces in the large serous visceral cavities of the body lined by a continuous endothelium, and which intervenes between the dura and arachnoid proper, is termed the *subdural space*; while the congeries of smaller cavities and meshes filled with cerebrospinal fluid in the subarachnoid tissue is known as the subarachnoid space. The delicate membranous sheets and webs of the latter are also lined by epithelium. The relations of the various membranous appendages and cavities surrounding the cord is shown in the following:

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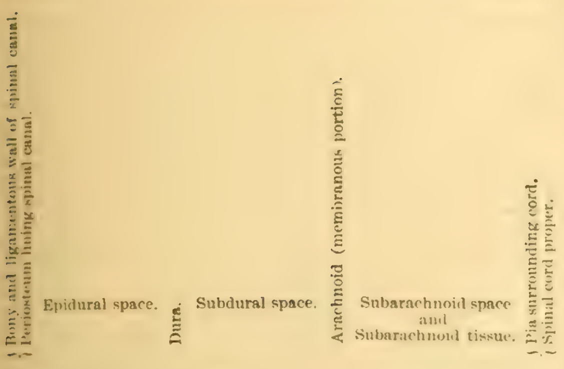
* This has [illegible] the *epidural space*. [illegible]

† [illegible]

‡ And is termed the filum *terminale externum*, a designation which [illegible]


Bony and ligamentous wall of spinal canal.
Periosteum lining spinal canal.
Epidural space.
Dura.
Subdural space.
Arachnoid (membranous portion).
Subarachnoid space and Subarachnoid tissue.
Pia surrounding cord.
Spinal cord proper.

Of the three slits which thus concentrically surround the cord, and facilitate its accommodating itself to the various flexions and rotations of the vertebral column during life, only the two innermost contain fluid, and that is of a serous character; the amount in the subdural space is very small, just sufficient to moisten the contiguous endothelial surfaces of the dura and arachnoid; that in the subarachnoid space is considerable.

The pia is composed of two connective-tissue layers. The outermost insensibly merges into the subarachnoid tissue, and is clothed by endothelium on its outer face. The inner layer, separated here and there from the outer by capillary slit-like spaces, is known as the *intima pia*; it contains elastic fibres and beautifully arranged circular fibrillæ. The vascular net-work of the pia is mainly situated between these, its two layers, and as they enter the substance of the cord receive an investiture from the intima, accompanied by a prolongation of the capillary slit-like spaces just referred to. These, in turn, are connected with the perivascular spaces, from which it results that the interior of the cord is traversed by a continuous lymphatic net-work connected with the spaces in the pia, and through these with the subarachnoid space.

Aside from the attachment afforded by the spinal nerve-roots and some delicate connective-tissue fibres uniting the dura to the arachnoid across the subdural space, the cord is mainly supported in its concentric protecting cavities by means of a series of triangular membranous processes, whose base is attached to the pia, and whose apex is attached to the dura. They flare out laterad from the lateral face of the cord, and are, on each side, between twenty and twenty-four in number. In their entity the series of each side are termed the ligamentum denticulatum (Fig. 5047, A, 9, 9, 9, shows dural insertion).

The blood-supply of the cord is derived from two sources: 1. The ventral (anterior) spinal artery, a median trunk with a double origin; and 2, the paired dorsal (posterior) spinal arteries. The former lies at the entrance of the ventral fissure of the cord, and continues in undiminished calibre for the entire length of the cord proper. It gives off, at nearly regular intervals, horizontal branches which pass to the depth of the fissure, and then penetrate, near the commissural part of the cord, to the mesal aspect of the ventral gray horn. The dorsal (posterior) spinal arteries send in similar but smaller branches at or near the dorsal roots, and in addition still smaller branches enter the numerous septa of the white substance, taking their origin in the surface net-work of the pia. Both the ventral system and the radiatory system of vessels send their main and their terminal branches to the gray substance, whose vascularity is so much richer than that of the white as to be estimated at between six and twelve times as great. It is a comparatively small number, and vessels of small calibre, which nourish the white substance, by means of a fine capillary net-work which surrounds the great longitudinal fibre system, and whose direction becomes vertical to that of the originating radiatory system.

The return circulation is mediated mainly by two large veins, the central veins of the cord, whose lumina constitute a characteristic feature of every section of the cord, being situated laterad of the central canal, in an almost directly transverse line with it. Numerous anastomosing branches connect it with the ventral (anterior) spinal vein, which accompanies the corresponding artery, lying dorsad of, or covered by, the latter. The dorsal (posterior) spinal vein takes up the return blood from the dorsal segment of the cord, by means of radiatory venules, and a surface net-work of the pia.

The lymph system of the cord is very intricate, and an important element in its physiology and pathology. Every blood-vessel, even the most minute, is ensheathed in a *perivascular lymph space*, which is lined by a continuous endothelium.[*] It has been recently demonstrated that the vascular and lymphatic channels of the cord have a direct connection with the perinuclear region of nerve-elements (Adamkiewicz). Of the largest kind of nerve-elements, it is now demonstrated that walled capillaries penetrate them, and that they thus have a circulation of their own (Fritsch).

There are in man thirty-three pairs of spinal nerves. Of these the two last, being rudimentary, are usually excluded in enumeration. The first pair emerges between the occiput and atlas, and is designated the first cervical, the other cervical pairs are named after the lower of the two vertebræ, which, conjoined, form the corresponding foramen, respectively the second, third, fourth, fifth, sixth, and seventh. Very inconsistently the pair emerging between the seventh cervical and first dorsal vertebra is termed the eighth cervical pair. The dorsal pairs are named after the upper of the two vertebræ which form the corresponding foramen, and this system is adhered to in regard to the lumbar, sacral, and coccygeal nerves.[†] We thus have:

Cervical pairs	8
Dorsal "	12
Lumbar "	5
Sacral "	5
Coccygeal "	3
	33 [‡]

All spinal nerves are made up of two roots by which they spring from the cord: the thus-far repeatedly mentioned dorsal (posterior or sensory) and ventral (anterior or motor) roots. A characteristic feature of the dorsal root, in which it differs from the ventral, is an intumescence made up of large nerve-elements, and known as the spinal ganglion (intervertebral ganglion). The conjoined spinal nerve, the two roots which build it up, and the spinal ganglion attached to the dorsal of these roots are to be regarded as part and parcel of the spinal segment.[§]

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[*] There is but one perivascular sheath, and that being endothelial, is sometimes known as the adventitial sheath. The extra adventitial sheath of His has no existence in the healthy cord.

[†] Willis endeavored to evade the unfortunate contradiction, which recognizes one more cervical pair than there are cervical vertebræ, by enumerating the first cervical, or suboccipital, as a cranial nerve. Consistency would seem to require either this, or the naming of all cranial nerves according to the vertebra just caudad of its intervertebral foramen.

[‡] Subtracting the second and third coccygeal pairs, which, as rudimentary, may be here disposed of, there are thirty one pairs, as usually stated in text-books. The two coccygeal nerves in question, like the coccyx itself, are rudimentary relics of the caudate condition of the human embryo, and, according to evolutionists, of the caudate ancestry of man. They are so minute as to require the microscope for their identification, and were, until Rauber discovered their true nature, confounded with the vascular and connective tissues surrounding the filum terminale.

[§] The few topographical facts of interest may be stated briefly thus: Inasmuch as the spinal nerves emerge at a much lower level than their true origin from the cord the sixth dorsal pair although emerging between the sixth and seventh dorsal vertebræ originating from the cord at the level of the fifth dorsal body, the fifth lumbar pair originating nearly six vertebral bodies higher than it emerges—the spinal ganglion attached to their dorsal roots does not always correspond to the intervertebral foramina after which it is named. The cervical and upper dorsal ganglia correspond very nearly, but those of the sacral nerves are half-way between the cord-origin and vertebral exit, while that of the first coccygeal pair is actually contained in the dural sac of the cord. All others lie outside of the dural sac.

The development of the true segmental part of each spinal segment bears a definite relation to the somatic segment supplied by its nerves. In man, the part formed by the dorsal roots in building up the segment seems to be slightly in excess of that formed by the ventral roots;* but in animals whose cutaneous and general sensory periphery has become reduced, this relation is inverted (Figs. [illegible] and [illegible]). The reduction manifests itself not alone in the afferent or dorsal root, but in the dorsal horn, in the dorsal root-zones, and the columns of Clarke—in short, in the segmental dorsal gray. The physiological anatomist hence discriminates between the gray matter connected with the dorsal roots and that connected with the ventral roots. The former he regards as related to functions involving centripetal conduction (sensation), the latter as related to centrifugal functions (motion, secretion). The variety of nerve elements connected with the dorsal roots is greater than that of those connected with the ventral roots, and our uncertainty of knowledge regarding them is correspondingly greater. While the ventral roots, on entering the cord-substance, follow a direct course, connecting with the multipolar elements of the ventral horn† or the nerve plexus in that horn, and the functional differentiation in the ventral part of the cord is determined by the relation of groups of these elements to special motor peripheral organs, it is not so with the dorsal roots. These, already complicated by the interpolation of special ganglia before their entry into the cord, present two distinct fasciculi within the latter, one of which directly penetrates the caput gelatinosum, or apex of the dorsal horn, the other, skirting on its mesal aspect, to penetrate the trigonum (Fig. [illegible], D).

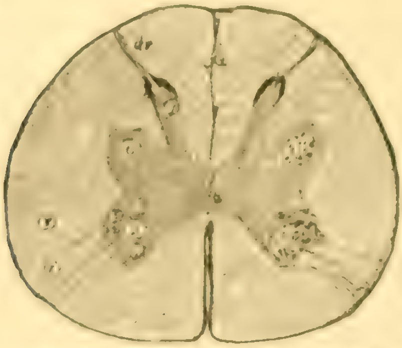

FIG. [illegible].—Transection of Terminal Cord from [illegible]. (*[illegible]*) *dr*, dorsal root; *v*, ventral [illegible]; [illegible] [illegible] of gray matter; [illegible] [illegible] groups of [illegible] ventral horn; [illegible], gray commissure.

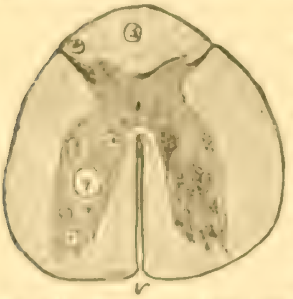

FIG. [illegible].—Transection from [illegible] [illegible] [illegible] [illegible] [illegible]; [illegible] ventral [illegible]; [illegible] [illegible]; [illegible] [illegible] [illegible] [illegible].

The ventral (anterior) face of the cord exhibits a deep fissure extending the entire length of the compact cord—the ventral or anterior fissure.‡ Cephalad this fissure becoming shallower through the crossing of the bundles of the pyramidal decussation, is continued into the interpyramidal or ventral sulcus of the oblongata. It is lined by the pia, and conveys the more important nutritive vessels to the depths of the cord-substance. On either side of this fissure, at distances varying with the diameter of the cord—being greater in the enlargements and lesser in the other parts—is a continuous series of fine rootlets which, at some distance from the cord, unite to form the anterior roots of the great spinal nerve pairs.

The dorsal (posterior) face shows a depression analogous to the ventral fissure, and which has been regarded as a dorsal or posterior fissure of the cord. But closer examination shows that, unlike the ventral fissure, the pia cannot be demonstrated to descend into and line the walls of the pretended fissure. The latter is merely a solid septum of connective substance bearing lymph and vascular channels. A very shallow sulcus marks it on the surface, which may be designated the *dorsal sulcus*, and which is particularly well marked in some in the lumbar cord. It becomes deeper in the oblongata, where it constitutes a veritable fissure between the clavæ. The solid septum which extends to the gray commissure, and in some levels is as deep as half the ventro-dorsal extent of the cord, is known as the *dorsal* or *post septum*.

About one millimetre to each side of the dorsal septum there is a shallow sulcus, continuous with that which, in the oblongata, forms the lateral boundary of the clava. This *sulcus [illegible]*, well marked in the cervical, becomes least of all marked in the dorsal cord. In a situation nearly corresponding to the origins of the ventral rootlets on the ventral face, a series of dorsal rootlets arise in a continuous row from a slight, furrowlike depression.

The principal points of resemblance and contrast between the ventral and dorsal faces of the cord are here summarized:

	On ventral face.	*On dorsal face.*
Median fissure . . .	Is a true fissure. Is [illegible].	Is [illegible] a septum. Is [illegible] but deeper.
[illegible] . . .	Absent [illegible].	Present in [illegible] part.
Root attachment . . .	No [illegible], [illegible] [illegible] [illegible] [illegible].	A [illegible] and [illegible] [illegible].
" "	[illegible] [illegible] [illegible] [illegible] [illegible] [illegible].	Is [illegible] gray [illegible].
" "	Inner limits of opposite [illegible] approach [illegible] nearly.	Inner limits of opposite [illegible] are farther apart.

A plastic conception of the various fissures, septa, sulci, and root-attachments of the cord is essential to an understanding of its inner topography. In Fig. [illegible] it has been attempted to show their relations, which may be embodied in the following propositions:

1. The ventral fissure from the ventral face and the dorsal septum from the dorsal face, penetrate so deeply into the cord-substance as nearly to meet. The cord is thus divided into two halves united by a very narrow bridge—the commissure. 2. On examining the cross-section of the cord, it is seen that the two forms of nerve-tissue known as gray and white substance (see [illegible] Histology, this volume) are represented in it, and arranged in a characteristic manner, which is constant in every region of the cord. The gray matter is interior, and the white exterior, in each half of the cord. 3. The gray core is drawn out into horns toward the emerging rootlets already mentioned. The one horn which extends toward the ventral roots is known as the ventral or anterior horn; the other, as the dorsal or posterior horn (Fig. [illegible]). 4. As the cross-section of each gray core is united across the middle line by a gray commissure, the aggregate appearance of the gray matter of the cord is that of a letter H. Furthermore, as the extremes of each horn join, or nearly approach, the emerging rootlets, there results a natural demarcation of the surrounding white substance into three great columns (Fig. 5053). The column whose cross-section is bounded by the ventral fissure mesad, the ventral roots and ventral horn laterad, is the ventral (anterior) column. The one similarly bounded by the dorsal septum mesad and the dorsal roots and horn

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* The [illegible] [illegible] area of all dorsal roots [illegible] [illegible] of all ventral roots [illegible] [illegible] [illegible] [illegible]. [illegible].

† [illegible] it is [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] to the [illegible] [illegible] of the ventral horn.

‡ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

laterad is the dorsal (posterior) column; the one between the two horns and roots is the lateral column. The ventral column has a free surface on the ventral face of the cord, the lateral on the lateral, and the dorsal on the dorsal.

Boundaries.	*Columns.*
Ventral fissure. Ventral horn and roots.	Ventral (anterior) column.
Dorsal horn and roots.	Lateral column.
Dorsal septum.	Dorsal (posterior) column.

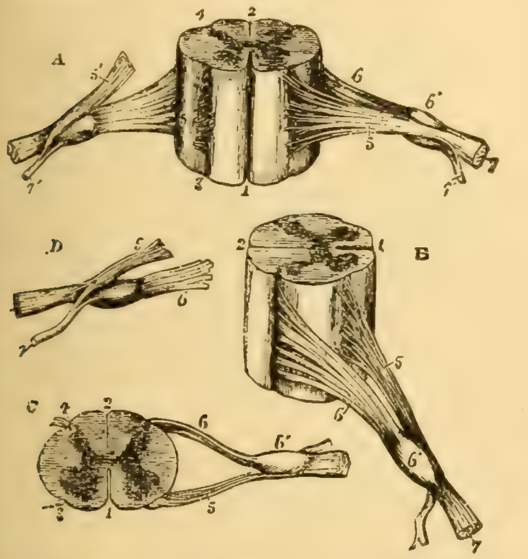

Fig. 5052.—Segments of Cord transsected so as to Separate the Part appertaining to one Spinal-nerve Pair from the next Segments above and below. (After Schwalbe.) A, the segment seen from its ventral face; B, seen from its lateral, and C, from its upper cut face; D, the relations of a spinal or intervertebral ganglion. 1, Ventral fissure; 2, dorsal septum; 3, spurious fissure left by evulsing ventral roots (in A they are enclosed on the left and retained on the right side); 4, sulcus for dorsal rootlets; 5, ventral, and 6, dorsal, root of spinal nerve; 6′, spinal ganglion; 7, proper root after leaving ganglion, subdividing into ventral and dorsal rami.

To have a proper conception of these various elements, they must be imagined not alone in the relations in which they are conventionally studied, that is, as exposed in transsections, but also as columnar structures having a continuous extent throughout the length of the cord. Each demicylinder of the cord is therefore to be conceived as containing a core of gray nerve-substance, drawn into a ventral ridge connected with the ventral roots, a dorsal ridge connected with the dorsal roots, while the white substance fills out the irregularities and completes the demicylindrical outline in three columns, one mesad of the ventral ridge, one mesad of the caudal ridge, and one between the two ridges.

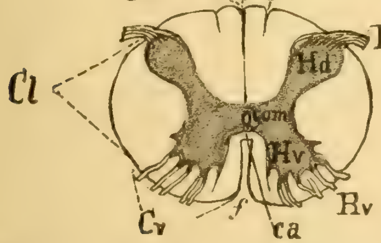

Fig. 5053.—Diagram of Transsection of Cervical Cord. The figures on the right side relate to the gray substance and emerging roots; those on the left side, to the white columns. *f*, Ventral fissure; *s*, dorsal sulcus; *Rv*, ventral (anterior) rootlets; *Rd*, dorsal (posterior) rootlets; *Hv*, ventral (anterior) horn; *Hd*, dorsal (posterior) horn; *com*, gray commissure with included central canal; *Cv*, ventral (anterior) column of white substance; *Cl*, lateral column; *Cd*, dorsal (posterior) column; *ca*, white commissure.

The commissure of the cord is, like each demicylinder, composed of both forms of nerve-substance. Its ventral part is white: *commissura alba;* its dorsal part is gray: *commissura grisea* (Fig. 5053, *ca*, and *com*). The ventral fissure, therefore, has for its floor the former, while the dorsal septum terminates on the latter. In the gray commissure is observed the lumen of a very small canal, which extends the entire length of the cord and into the filum. It opens cephalad into the fourth ventricle, and represents in the cord what the ventricles do in the brain, the medullary canal of the embryo (see article on Brain, Development of the, in Vol. I.). While this canal undergoes elaborate transformations in the cerebral part of the neural axis, it becomes so much reduced in the adult cord as to be identifiable by the microscope alone. Formerly it was assumed by some to open into the ventral fissure; by others, in the dorsal septum of the sacral part of the cord; it is now definitely ascertained to be continued through the filum,* which is the true caudal representative of the cord, in every morphological essential. The gray substance of the cord is of a faint reddish-gray tinge. In older persons the gray preponderates, and, according to the degree or absence of capillary injection, various shades of red, yellow, and even light slate-color may be noted. It is not uniform in this respect, even in the same section. Around the central canal, and in a particular band on the dorso-mesal periphery of the dorsal horn, it is very translucent and is termed gelatinous substance, that in the former situation being additionally qualified as the ***substantia gelatinosa centralis***, that in the latter as the *caput gelatinosum* † (Fig. 5054, *gc*, and *S. g. R.*).

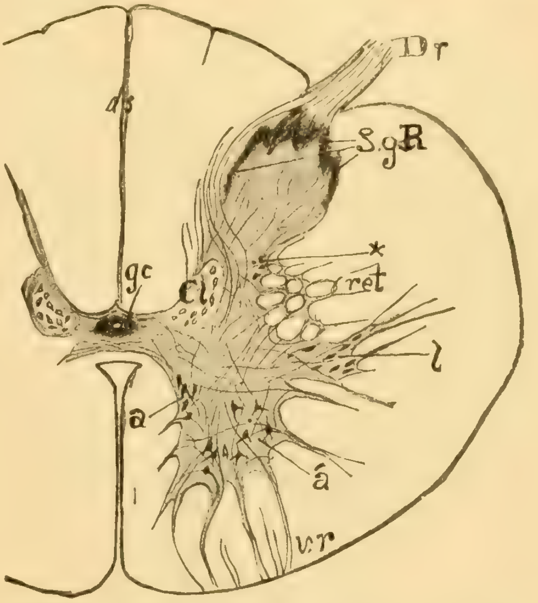

Fig. 5054.—Diagram of Gray Matter in a Transsection of Cord, combined from an Upper Cervical and a Middle Dorsal Level. The gelatinous substances are indicated by deep shade; the vesicular, by a light area with spots (nerve-elements); the spongy, by light shading and intersecting lines. *S.g.R*, caput gelatinosum; *gc*, substantia gelatinosa centralis; *Cl*, vesicular column of Clarke; *Dr*, dorsal or posterior roots; *v.r*, ventral or anterior roots; *a*, *a′*, *l*, *ret*, *, spongy substance; *a*, *a′*, cell-groups in ventral horn; *l*, in lateral horn; *ret*, reticular processes; *, sparse cells found at and near neck of dorsal or posterior horn; *ds*, dorsal or post septum.

In the cervical and dorsal cord, another area of gray matter is noted for its remarkable pallor. This it owes to the abundance of numerous myelinic fibres. From its columnar extent and Lockhart Clarke's demonstration in it of special vesicular nerve-elements, it is known as the vesicular column of Clarke (Fig. 5051). There are two, one on each side. To understand their situation it is necessary to refer to a feature of the contour of the dorsal horn hitherto not yet considered.* The horn is more massive at its connection with the nerve-root than at its junction with the remainder of the gray. The massive part is known as the head (*caput cornu dorsalis seu posterioris*), the narrow part as the neck (*cervix cornu*). Where the neck joins the gray commissure the vesicular columns of Clarke are found to occupy a triangular area: one acute mesal angle is directed toward (and sometimes encroaches† on) the commissure; another points toward the dorsal-root entry; the third rounded angle is directed lateral. The remainder of the gray substance, that is, all excluding the columns and the two gelatinous areas, is designated spongy substance. It corresponds in structure nearly with the motor nerve nuclei of the brain (see Brain Histology). The entire ventral horn, and, when present, that lateral peninsular extension of it which is sometimes termed the lateral horn (Fig. 5053), and the neck and body of the dorsal horn, are made up of this substance. It owes its characteristic features to the intrusion of a large number of myelinic and amyelinic nerve-fibres, which interlace in a bewildering manner, and hold in their meshes groups of nerve-cells and other structures to be described. Toward the ventral roots it is drawn out into projections, giving its outline a very irregular shape; and facing the lateral column it is broken up in a peculiar basket-work pattern by intruding nerve-fibres, causing an appearance, on a smaller scale, like that of the reticular field of the oblongata (*processus reticularis*, Fig. 5054, ret.).

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* Its primitive embryonic relations (neur-enteric canal) are obliterated in the adult.

† Substantia gelatinosa Rolandi; it is continued into the oblongata and here becomes so massive as to force the overlying tissue out in the shape of the funiculus Rolandi (see Brain Histology).

Structure of the Central Gelatinous Substance.—Immediately adjoining the epithelia of the central canal, and gradually merging into the spongy substance which constitutes the remainder of the gray commissure, is a finely granular substance containing numerous free (?) nuclei and granular elements. Extremely fine nerve-fibrils are found among them, and often such appear to be connected with, or to meander among, the epithelia of the central canal.‡

Structure of the Caput Gelatinosum.—This substance clings to the spongy substance of the body of the dorsal horn like a tight-fitting cap. It is more voluminous in the cervical and lumbo-sacral enlargements than in the dorsal cord. Chemically it shows the reactions of nerve-substance; it stains very deeply in carmine. Opinion as to its histological nature has oscillated between every possible extreme, and until recently the view prevailed that it was not a nervous, but a connective, substance, acting as a "support" to the dorsal rootlets. Against this view it could be urged that higher animals, which have, as a rule, less connective substance than the lower, have a better developed caput gelatinosum.§ Further, this structure wastes in tabes dorsalis, although in that disorder the connective substances are increased. Finally, experiments performed after the atrophy method show that this substance depends for its nutrition on the intactness of the dorsal nerve-roots, or their sensory periphery. Recently Virchow the younger has conclusively shown that it is not composed of free nuclei, as was the general belief. He finds that each nucleus has its proper protoplasm and the other characteristic nerve-processes, but all so closely crowded that previous observers overlooked the demarcation between the various cells, regarding it as a uniform blastema. It may be affirmed, then, that the *caput gelatinosum* is a nervous substance composed of numerous closely crowded nerve-elements allied to the "granule type" of nerve-cell, with an intricate intervening plexus of very fine nerve-fibrils, derived from the dorsal (posterior or "sensory") nerve-roots. Of these some traverse it in a manner analogous to the arciform fibres which break through the dentated nucleus of the olive (Brain Histology), while others are lost at its periphery or interior.

Structure of the Spongy Substance.—The ground substance of this, the chief gray matter of the cord, is neuroglia or nerve-glue, a substance described in the article on Brain Histology. It is everywhere penetrated by nerve-fibres, some of which are derived from the nerve-roots, some from the great fibre-tracts of the cord, while others probably remain in the gray substance throughout their entire extent. They are of all dimensions, from the large axis-cylinder processes and myelinic fibres connected with the roots and fibre-tracts to fibrils so delicate that their very nature has been disputed.

One of the most important features of the spongy substance is the presence of multipolar nerve-elements. These are distributed in constant and definitely located groups. On pursuing the course of individual nerve-rootlets, it is seen that in running through the gray substance each spreads and forms a loop enclosing a cluster of these elements. Each group is demarcated from neighboring groups by the nerve-fibre intervals, and has a special situation in each level. Numerous pathological observations, chiefly based on the atrophy of special cell groups as related to mutilation or atrophy in special groups of muscles, whether caused by amputation, congenital absence of limbs, or infantile paralysis, show that they have a definite relation to certain muscles or organs endowed with muscular activity.

The structure of the large multipolar elements of the spongy substance is essentially the same as that of the similar elements in the cerebral cortex and cranial nerve nidi. An irregular mass of protoplasm, sometimes drawn out into a conical, more frequently a polygonal, shape, presenting numerous branching processes, is their essential constituent. In addition, they contain a clear, well-marked nucleus, round, oval, and sometimes angular, which appears to vary in staining reaction and contour, in conformity with certain nutritive or vital conditions of the cell itself, which are as yet imperfectly known. The largest elements have one* unbranched process of large size, which may frequently be traced into the axis-cylinder of a ventral nerve-root. In dimensions the multipolar elements vary considerably; large and small ones, presenting every transition to granular elements, can be found in every section. But the average size corresponds to the size of the muscular masses to which they are in demonstrable functional relation. They are therefore larger and more numerous in the cervical and lumbo-sacral intumescences than elsewhere in the cord; and here again, more bulky in the lumbo-sacral than in the cervical enlargement, just as the thigh muscles exceed those of the arm.

The manner in which the motor functions of the groups of multipolar nerve-elements is determined, is so intimately connected with the topography of the ventral and lateral horns of the cord that we may briefly state them. Certain mammals, such as the sloth, are characterized by a preponderance of flexor and ventral muscles over extensor and dorsal muscles. Others, such as the dolphin, have enormous extensors and dorsal muscles. On comparing the spinal cord of the dorsal levels of these two animals, it is found that in the sloth the radicles of the ventral or motor roots are more numerous in the mesal and in the dolphin more numerous in a lateral situation. Correspondingly, the cell groups in the mesal part of the ventral horn preponderate in the sloth, while those in the lateral part preponderate in the dolphin. From this fact it may be inferred that ventral muscular masses of the trunk are represented in mesal and dorsal

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* This feature is not marked in the cervical and lumbar enlargements, but in the dorsal cord the horn is so attenuated that what is termed caput cornu [illegible] is [illegible].

† Aberrant varieties have been found by Pick (Arch. f. Psychiatrie, vii., p. 287) the areas of [illegible].

‡ In lower forms the central epithelia have been connected with fibres which are apparently identical with nerve-fibres. It is not surprising when we remember that the ependymal epithelium and the proper nerve-elements are both products of an identical embryonic tissue.

§ In man it actually shows a tendency to [illegible] exceeding those of the [illegible].

* Observers describe some elements with more than one process.

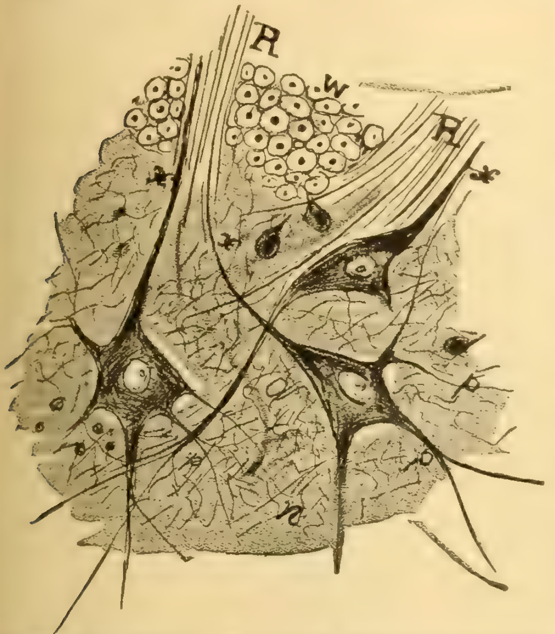

FIG. 5055.—Large Multipolar Elements from Ventral Horn in Cervical Enlargements. *R*, Ventral root fibres; *xx*, axis cylinder processes; *p*, protoplasmic processes; *n*, neuroglia of gray substance; *w*, white substance, showing myelinic fibres in cross-section.

ones in lateral cell groups. In all animals it is noted that, in the cervical and lumbo-sacral enlargements, the lateral part of the ventral horn is particularly well developed. Here the nidal * centres of the extremity muscles are to be sought for. In part, they may be located by means of their direct relations to nerve-roots, whose function has previously been determined by experiment, or by pathological observation already referred to. Thus amputation of the forearm is followed by a wasting of the cell groups at the levels of the seventh and eighth cervical and first dorsal nerves. Other similar observations show that within this extensive area, it is a more specialized one which is related to the muscles of the thumb. In like manner, the observation of cases of fracture at the level of the first lumbar vertebra proves that it is below the level of the intervertebral cartilage, intervening between the last dorsal and first lumbar vertebra, that the centre for the rectum and bladder is to be located. In the cetacea, the enormous atrophy of the extremity nuclei throws out the nucleus sacralis † in bold relief by contrast, and thus, pathological and comparative anatomical facts unite in pointing to this nucleus as the presumable centre for certain pelvic innervations. It corresponds to the origins of the third and fourth sacral nerves.

The groups related to special muscular masses are not strictly segmental; they often extend caudo-cephalad beyond a segment, and in successive sections their area varies considerably, and like the subnuclei of certain cranial nerves, they overlap each other (Brain Histology). The following have been well established: 1. A group in the lateral part of the ventral horn, which is the nidal centre of the sterno-cleido-mastoid and trapezius (see Spinal Accessory Nidus in article Brain Histology). 2. A powerful group extending from the fourth beyond the fifth cervical level, representing the great muscles of the shoulders (deltoid, supra and infra spinatus); it is located laterad on the root border. 3. Mesad of it and overlapping it, but mainly developed in the fifth and sixth levels, is the nidal centre of the pectorals. 4. From the sixth cervical to the first dorsal inclusive, are a number of overlapping groups related to the forearm and hand muscles, of these (5) one well-marked group in the last cervical and upper dorsal level, and consisting of several subgroups, is positively related to the great muscles of the thumb and those of the thenar eminence. Those of the hypothenar eminence are probably represented in another group of these levels. Less is known of the lumbar enlargement. 6. It is generally held that in the conus, as above stated, are located the atrophied coccygeal (caudal) centres, together with the well-developed centre for the bladder and rectum (nidus or nucleus sacralis); that immediately cephalad of this (7), from the level of the fifth lumbar to the second sacral origins, is the centre for the peronei and intrinsic muscles of the foot. 8. The columns of Clarke may each be regarded as a nidus of unusual length; they extend from the level of the eighth cervical origin.

Aside from the above, physiologically significant variations in the essential nervous elements of the cord, the local peculiarities of the special regions are epitomized in the following:

The *conus terminalis* is characterized by the predominance of gray over white substance. The latter is a mere thin rind of the former, particularly in the lateral column. The gray substance shows a very deep commissure, with very plump horns. The root entry is at so steep an angle that the radicles usually appear cut across obliquely (Fig. 5049, Co 1).

In the *lumbo-sacral enlargement*, the gray substance contributes most to the cord area, being absolutely more voluminous than in the cervical region. As we pass cephalad the commissure becomes gradually more attenuated, but the horns are more plump in contour than in the cervical region (Fig. 5049, Sac 2, L5, L3). The dorsal roots enter in a compact mass, and the belting fibres of the so-called root zones are particularly well marked. The caput gelatinosum is voluminous. At the upper part of the enlargement (Fig. 5049, L3, L1) the white substance attains more volume, owing to the beginning here of the crossed pyramid tract, and the tract of Goll's column.

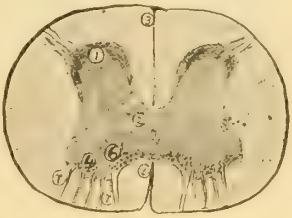

FIG. 5056.

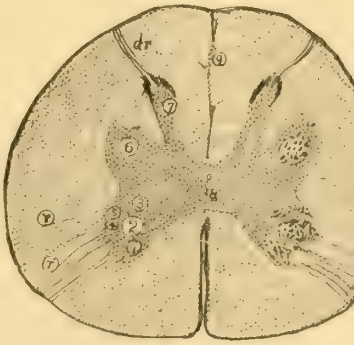

FIG. 5057.

FIGS. 5056 and 5057.—Transsection of Cervical Cord of Sloth and Dolphin, to exhibit contrast in radicular and nidal relations. Fig. 5056, Transsection of cord of sloth; 1, caput gelatinosum; 2, commissural gray; 3, dorsal or post-septum; 4, lateral cell group; 5, ventral sulcus; 6, mesal cell group; *r*, *r*, ventral rootlets. Fig. 5057, Ditto from Dolphin; 9, post septum; 8, commissural gray; 7, diminutive dorsal horn; *dr*, dorsal root; *r*, *r*, ventral roots; 1, 2, 3, 4. 5, numbers corresponding to location of cell groups on unnumbered side; 6, the large dorso-lateral group.

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* For explanation of this term see Brain Histology.

† So named by Stilling. Schwalbe regards it as a disconnected homologue of the columns of Clarke.

The dorsal cord (Fig. 5049, D12 to D2) is throughout characterized by a relative diminution of the gray substance, which appears in the typical H shape, with attenuated horns and small cell groups. A prominent feature is the presence throughout its extent of that paired area in the gray known as Clarke's vesicular column. A lateral spur is very distinct on the dorso-lateral part of the ventral horn, and sometimes spoken of as the lateral horn. The white substance continues increasing cephalad, but very slightly; the main increase is due to the addition of the direct cerebellar tract.

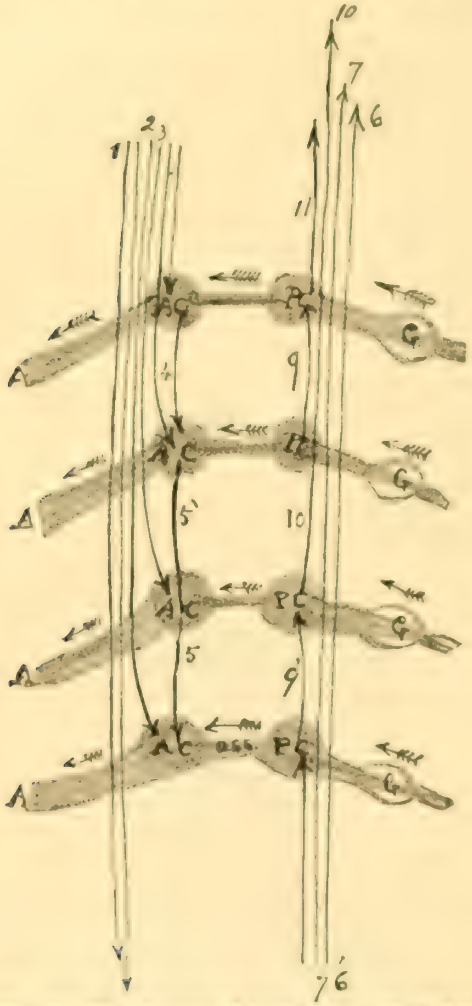

FIG. [illegible].—Diagram of Segmental Relations of Cord. [illegible]

The cervical enlargement gradually begins with the first or most cephalic dorsal segment, and extends to the fourth cervical segment inclusive. The general outline is transversely oval, both the gray and the white substances undergo a sudden increase. The gray horns have a more slender and graceful outline than in the lumbar region, and the white substance is at least twice the square area of that of the first lumbar level. The dorsal septum is consequently half as deep again as in the latter situation. A collateral sulcus, indistinctly marked in the middle dorsal levels, increases in distinctness in the cervical, and as we pass further cephalad. All the great known fibre systems are represented in the white columns.

The *upper cervical cord* shows the same relations of the white columns, which continue increasing; but owing to a collapse of the gray, similar to that observed in passing from the lumbar to the dorsal levels (Fig. 5049, C), the general contour becomes more round.

The *cephalo-cervical transition area* extends from the level of the upper cervical nerve pair to the clava. The cord shows its greatest volume of white substance here, as all the great tracts, whether centripetal or centrifugal, increase in area cephalad. At the same time the ventral horn becomes smaller, while the caput gelatinosum undergoes a great development, and the neck of the dorsal horn becoming elongated, the former becomes situated more laterad (Fig. 5049, C 1). It is the increasing volume of the dorsal white columns that drives the dorsal cornua aside. The reticular processes are also increased in number and area. The strands of the crossed pyramid tract insinuate themselves among these processes, and breaking through the body of the gray matter so as to decapitate the ventral horn, they cross the median line to apply themselves ecto-ventrad of the direct pyramid tract. The united pyramid tract thus causes a ventral prominence or column on the oblongata, to which it owes its name. After the translocation of the pyramid tract the column of Goll and the comma-shaped area of the column of Burdach end in two gray masses, the correspondingly named nuclei, and the spinal type of structure becomes gradually abolished, although some of its ingredients may be identified for considerable distances cephalad in the oblongata, and even in the pons. The transition from the cord to the oblongata is epitomized in the following table:

Cord Structure.	*Condition in Oblongata.*
Dorsal or postseptum.	Becomes a true fissure.
Column of Goll.	Isolated by its nuclear termination beneath the clava.
Column of Burdach.	Becomes a nucleus of the same name.
Ascending root of trigeminus.	Continued and augmented.
Caput gelatinosum.	Continued and augmented.
Direct cerebellar tract.	Moves more and more dorsad, and associates itself more cephalad to merge into the restiform, cerebellar peduncle.
Crossed pyramid tract.	Decussates and is extracted from the lateral to become added to the ventral pyramid.
Reticular processes.	After interruption by pyramid tract become augmented.
Ventral horn.	Becomes reduced to a rudiment, from which, as a starting point, the nuclei necessarily originate.
Ventral fissure.	Becomes shallower, the pyramid decussation taking place at its floor; cephalad of this it becomes the ventral or anterior longitudinal fissure of the oblongata.
Ventral or white commissure.	Undergoes a great increase and becomes identified with the decussation of the pyramids.
Dorsal or gray commissure.	Becomes augmented; at the part where the ventral horn was decapitated the hypoglossal nucleus and in a more dorsal situation the vagus nuclei are found.
Central canal.	Continues, to eventually open in the fourth ventricle.
Dorsal nerve roots.	Absent; nerve roots of the sensory and vegetative nuclei of the cranial nerve system may be regarded as their analogues.
Accessory nerve roots.	Continued in a corresponding situation.
Ventral nerve roots.	Represented by the hypoglossal roots.

Each spinal segment is composed of two sets of elements. One of these is strictly segmental; its gray and white tissues are in direct relation to the nerve roots which are connected with that segment. The gray matter in which these roots terminate, the rootlets themselves, and the intra-cinereal tracts which mediate reflex relations, have this character. But most of the strands of the white columns are not segmental, they simply traverse the segment to terminate in segments situated more caudad, if centrifugal; with segments more cephalad, or even with cerebral centres, if centripetal. To illustrate this, let us assume a segment in the cervical region. The motor (ventral) and sensory (dorsal) roots of the seventh cervical pair, the ventral and dorsal gray from which these roots arise, are the segmental morphological elements of that level, and, physiologically speaking, represent the reflex functions of the corresponding somatic segment. The pyramid tract, exposed on a cross-section at this level, is not segmental, as it runs caudad to the next succeeding levels, and in its greater part represents innervations of lumbar and sacral segments. In like manner the column of Goll, exposed on cross-section in this level, has no physiological relations to cervical nerve-roots or cervical gray matter. It is in relation with sacral and lumbar segments, and merely traverses the cervical segment to reach a higher cephalic destination. It is therefore necessary, in studying the anatomy of a given spinal segment, to discriminate between the true segmental part, which, crudely expressed, may be regarded as a reflex apparatus, and the non-segmental part, which represents more complex associated, or even cerebral, innervations. Among the tracts of each segment which add to the volume of the spinal cord in the enlargements are those of the ventral commissure. This commissure is more voluminous in the enlargements than in the remainder of the cord. The intersegmental, or short longitudinal tracts, are similarly more numerous in the enlargements, consequently the increased bulk of the cord in the enlargements is not alone due to the greater volume of the entering nerve-roots, the greater mass of the gray substance, but also to a local increase in the white columns.

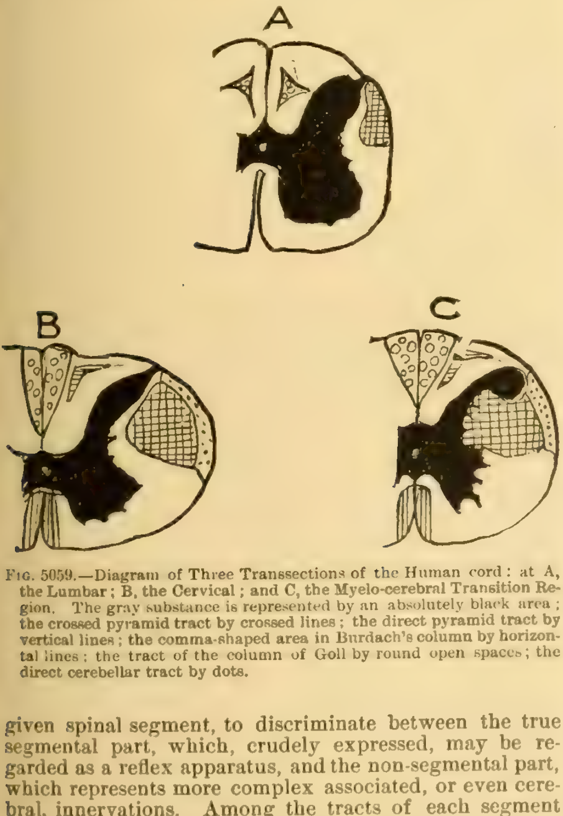

FIG. 5059.—Diagram of Three Transsections of the Human cord: at A, the Lumbar; B, the Cervical; and C, the Myelo-cerebral Transition Region. The gray substance is represented by an absolutely black area; the crossed pyramid tract by crossed lines; the direct pyramid tract by vertical lines; the comma-shaped area in Burdach's column by horizontal lines; the tract of the column of Goll by round open spaces; the direct cerebellar tract by dots.

The non-segmental or great longitudinal tracts, in so far as they are connected with the architecture and mechanism of the brain, have been already considered in the article on Brain Histology. It remains to describe their spinal relations in various levels, and to consider those tracts whose cerebral relations are as yet unknown.

The area occupied by the cerebro-spinal fibre systems is indicated in Fig. 5059. It is there shown that all these tracts increase cephalad, occupying a greater area in the myelo-cerebral transition (C) than in the cervical enlargement (B), and in the latter than in the lumbar region (A). In the latter only the tract of the column of Goll, and the crossed part of the pyramid tract, are represented. The direct cerebellar and direct pyramid tracts are added in the dorsal, and the comma-shaped area of Burdach's column in the cervical regions.

The *dorsal white columns* of each side are usually distinguished as the column of Goll (slender column, *funiculus gracilis*) and that of Burdach (wedge-shaped column, *funiculus cuneatus*). In the greater extent of the cord they can be readily recognized by means of the sulcus collateralis, or a septum which represents the latter. Further, the column of Goll has a distinctly different tinge, even in the fresh cord, and assumes a darker color in carmine than the column of Burdach. In the lower part of the lumbo-sacral enlargement it appears to originate as a triangular area on either side of, and at some distance from, the dorsal septum, and to grow out of the gnarled and twisted fasciculi resulting from the intertwining of longitudinal and root-fibres. Whether it originates directly from the root-fibres, or indirectly after interruption in the gray substance, is not yet determined; but this is positively known: 1. The tract of the column of Goll atrophies, if the lower extremity of the same side be amputated. 2. It atrophies and degenerates in an ascending direction. 3. It receives no demonstrable accession of fibres above the lumbar enlargement. 4. It runs cephalad to terminate in the nucleus of the same name. 5. That nucleus is connected with the interolivary tract; lesion of which latter, it is generally admitted, produces

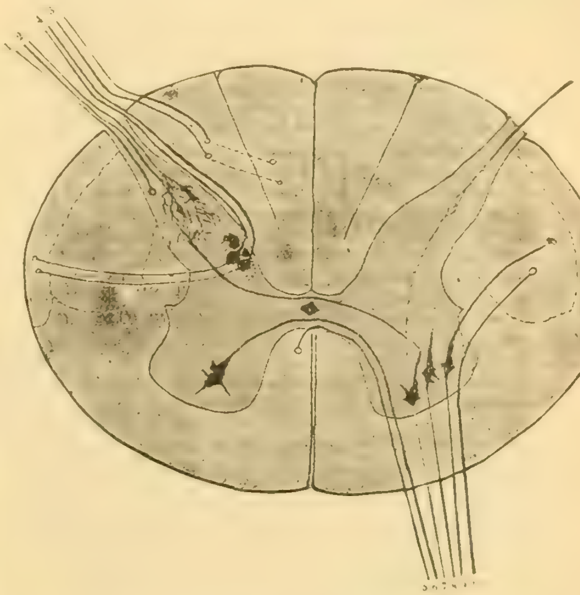

FIG. 5060.—Diagram of Transsection of Cord in Cervical Enlargement (after Edinger), showing Segmental and Non-segmental Tracts in their Root Relations. 1, 2, Direct fibres connecting with proper substance of the dorsal horn; 4, mesal tract connecting with the columns of Clarke; 3, tracts which ascend and descend some distance in the column of Burdach, whose destiny is not clearly known, but some of which enter the column of Goll; 5, a ventral root fibre derived from the direct pyramid tract, through the ventral commissure; 6, one derived from the opposite ventral horn through the same commissure; 7, one derived from a ventral horn cell of the same side, with reflex intra-cinereal crossed tract, indicated by a dark, and a direct (homolateral) tract indicated by a broken, line, which latter extends to the dorsal horn; 8, root-fibre from a cell with undemonstrable central connection; 9, a fibre derived from a multipolar cell, under the dominion of the crossed pyramid tract; 10, a direct root-fibre from the crossed pyramid tract; 5, 8, and 10 are supposititious tracts, and their existence is disputed.

disturbance of sensation. 4. The only form of sensation which accompanies at the myelo-cerebral transition is experimentally (Brown-Séquard) known to be the muscular sense. From all this it is inferred that the tract of the column of Goll represents the muscular-sense projection for the lower extremity of the same side.

The column of Burdach, unlike that of Goll, does not present a physiological unit. The largest and best individualized tract in it is represented on cross-section by a comma-shaped area (Fig. 5000, B and C). It originates in the cervical enlargement, increases cephalad, and terminates in the nucleus of the column of Burdach.* From its resemblance in structure, its participation in [illegible], and its analogy in termination with the tract of Goll's column, it is to be inferred that it represents the muscular-sense projection for the upper extremity.

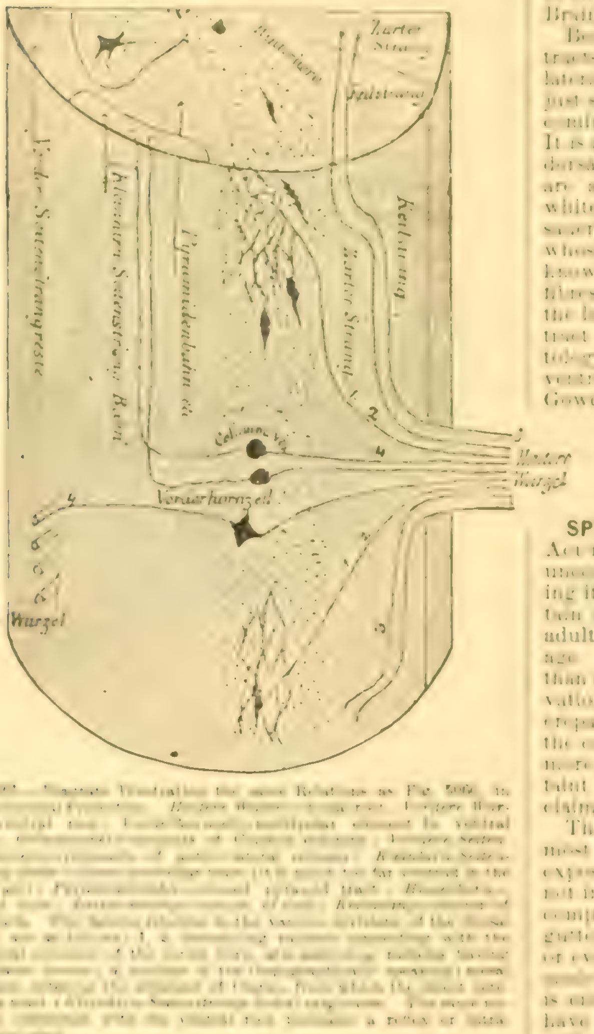

Fig. 5001.—Diagram Illustrating the same Relations as Fig. 5000, in Longitudinal Projection. [illegible]

The direct cerebellar tract lies on the periphery of the cord, and in direct contact with the pia, intervening between it and the crossed pyramidal tract (Fig. 5000, B and C). Only where it is absent, as in the lumbosacral enlargement, does the crossed pyramidal tract come in contact with the pia. It nearly reaches the dorsal root entry, and extends on an average over one-half to two-thirds of the periphery of the lateral column. On a cross-section it is seen that delicate nerve-bundles, originating in the columns of Clarke, traverse the gray substance, the pyramidal tract, and spreading out fan-shaped, enter and build up the direct cerebellar tract. Inasmuch as the columns of Clarke are themselves in relation with the dorsal roots, it follows that they are to be regarded as an interrupting station for a continuous tract, beginning in certain dorsal nerve roots and terminating in the cerebellum—for in the cerebellum (see Brain, Histology) the direct cerebellar tract eventually extends as an ingredient of the restiform column. Fig. 5000 shows this relation in transsection and Fig. 5001 in longitudinal projection. One unexplained fact is, that although segmentally the columns of Clarke belong to the dorsal region, in atrophic experiments they seem to be under the dominion of dorsal lumbo-sacral roots. They waste with disease of these roots and after amputations. Opinion as to their function varies, as stated in the article on Brain Histology.

Besides the direct cerebellar and the crossed pyramidal tracts, which make up the dorsal and greater part of the lateral column, there is a narrow rim of white substance just sufficient to prevent the crossed pyramidal tract from coming in contact with the dorsal horn and dorsal roots. It is assigned a special position under the dominion of the dorsal root; its further relations are unknown. There are a number of fibre systems contained in the zonal white surrounding the dorsal horn, described by Lissauer, and in the gray substance itself, described by Pal, whose exact significance is yet to be determined. Our knowledge of the destination of the greater part of the fibres of Burdach's column, and of the ventral part of the lateral column, is equally uncertain. The triangular tract of Helweg, referred to in the article on Brain Histology, appears either in juxtaposition with, or the most ventral part of, the antero-lateral tract described by Gowers, Sherrington, and Toothe. As described by the latter, it occupies a peripheral zone continuous, as it were, with the area of the direct cerebellar tract, in transsection.

E. C. Spitzka.

SPINAL CORD: ACUTE AND CHRONIC MYELITIS.

Acute Myelitis.—*Etiology.*—Acute myelitis is not an uncommon disease, though very little is known concerning its predisposing factors. With the exception of certain special varieties, it is usually a disease of early adult life, and grows more infrequent in middle and old age. The male sex seems to be much more predisposed than the female. Thus, among 33 cases under my observation there were 20 males and 13 females. This discrepancy is probably owing to the greater frequency of the exciting causes among males. Whether myelitis is more frequent in families suffering from a neuropathic taint is more than doubtful, though this has been claimed by some writers.

The exciting causes of myelitis are numerous. The most frequent one, in the writer's experience, has been exposure to cold and wet. Thus, the disease is observed not infrequently after a debauch, if the patient has been compelled to sleep on the damp ground, or lie in the gutter, etc. It may also result from working in ditches, or even from a brief exposure to wet and cold. The modus operandi of exposure in the production of myelitis is entirely unknown, although numerous experiments have been made to solve the question.

Traumatism plays a much less considerable part in the etiology of this disease. The injury may be inflicted directly upon the spinal cord, as the result of gunshot and stab wounds, direct blows to the back, or even blows on the head. Injury to adjacent parts may also lead to myelitis. For example, in one of the writer's cases an injury to the back gave rise to a myositis in the erector spinæ muscle, attended with suppuration. After a long interval the pus made its way along the roots of the spinal nerves, through the intervertebral foramina, to the pia mater, where it set up an acute meningitis, and then extended to the substance of the cord, setting up myelitis. A certain amount of myelitis always attends spinal meningitis, but it is usually confined to the outer layers, and does not produce any notable symptoms.

Myelitis is also a frequent result of injuries to the spine (fractures, dislocations, etc.) which are attended with direct pressure on the cord; or it may occur in spinal concussion, when there is no evidence of injury to the external parts. In the latter form, however, the myelitis is more apt to be subacute or chronic.

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* [illegible]

Compression-myelitis is also observed quite often, usually as the result of Pott's disease, more rarely of cancer or other tumors of the vertebræ. In Pott's paraplegia the inflammation rarely results from direct pressure of the bones, but usually from that of a secondary pachymeningitis, externa and interna.

Attention has been directed in recent times to myelitis, commonly of the disseminated variety, occurring after infectious diseases, usually small-pox, but also after typhoid fever, diphtheria, puerperal fever, etc. This is also claimed by many writers with regard to syphilis, but our own experience does not corroborate this very strongly. Barlow reports a case of disseminated myelitis occurring during the eruptive stage of measles, and which proved fatal on the eleventh day of that disease. The occurrence of myelitis during the course of phthisis is very often noticed, but the connection between the two affections has not been clearly determined. To one point, however, we desire to call attention, viz., that tuberculosis of the spinal dura and pia mater is much more common than is generally believed. We have found it frequently in cases of tubercular cerebral meningitis, and in two cases the tubercles projected inward from the spinal pia mater to such an extent as to cause considerable softening. Perhaps the development of tubercles within the substance of the cord may also occur at times, and thus serve to explain the frequency of the disease during the course of pulmonary tuberculosis.

We may here state that certain cases of acute myelitis are regarded by some writers as an infectious process, resulting from the action of bacteria. But this view is a mere hypothesis, for which no proof has hitherto been offered.

A considerable number of cases have been reported, in which the disease was attributed to excessive fatigue. For example, it has been noticed in soldiers after forced marches, and is then supposed to be due to overaction of the spinal cord.

Toxic myelitis is also observed occasionally after poisoning with arsenic, lead, phosphorus, sulphide of carbon, and vegetable poisons.

Much stress was formerly laid upon the effect of ascending neuritis in the production of myelitis after disease of the bladder, kidneys, etc. This mode of origin must be extremely rare. There is no doubt that, in many cases which have been regarded as belonging to this category, the disease of the urinary tract was secondary to that of the spinal cord.

Finally, in a considerable proportion of cases, we are unable to discover any adequate cause for the development of the disease.

CLINICAL HISTORY.—Acute myelitis is rarely preceded by prodromal manifestations, unless this term be applied to the first symptoms of the beginning inflammation. In rare cases there is a feeling of general malaise, slight shivering sensations, or a distinct chill, and there may even be a certain degree of mild delirium; even general convulsions have been noticed at the onset of acute dorsal myelitis, and still more often in cervical myelitis. Marked febrile movement is not often noticeable, however acute the inflammation may be. There are several varieties of acute myelitis, the symptoms of which differ somewhat in numerous details.

The onset of acute myelitis varies considerably in its degree of suddenness. In rare cases it begins as quickly as an attack of cerebral apoplexy. The patient suddenly feels a sense of weight in his lower limbs, this increases, and at the end of a few minutes the limbs are paralyzed. Or the onset extends over a week or more. At first a feeling of numbness, or of pins and needles, is felt in the soles of the feet; this gradually spreads up the limbs, accompanied by increasing weakness of the parts, perhaps by severe pains in the muscles, particularly the calves of the legs, or by painful spasms of the muscles. Then the anaesthesia and motor paralysis continue to increase, sometimes uninterruptedly, sometimes by fits and starts, until they have attained their greatest intensity. The paralysis may be so complete that the patient is unable to move even the toes to the slightest extent.

Pain in the spinal column is not a pronounced symptom, nor do the patients, as a rule, complain much of tenderness in this region. The pains in the paralyzed muscles, sometimes in the joints, are extremely violent in certain cases, so that we have even seen this condition mistaken for acute articular rheumatism. These pains may continue during the entire acute stage of the disease. A more constant symptom is the cincture feeling, a term applied to a painful sense of constriction around the abdomen, or thorax, varying according to the site of the disease in the spinal cord; this is usually attended with circumscribed tenderness over the corresponding portion of the spine. The cincture feeling is sometimes described by the patients as very narrow, like a cord or thin ribbon; sometimes it is as broad as the hand.

In the majority of cases the pains in the limbs disappear as the paralysis becomes more pronounced, but in some instances they persist, even despite complete motor and sensory paralysis (anæsthesia dolorosa). When the pains in the limbs are severe they are usually attended with spasm or contracture of the affected muscles.

The bladder and bowels, especially the former, are usually implicated at an early period. The patient first experiences difficulty in passing water (paralysis of the detrusor), and must strain a good deal to start the flow. Finally, the paralysis of the detrusor may become complete, and the use of the catheter becomes necessary. Or the sphincter also becomes paralyzed, and incontinence results from overflow. The bowels are affected in a similar way, though less frequently. At first there is constipation, sometimes attended with extreme tympanites, from paralysis of the muscular coat of the bowels. Or the stools may pass away involuntarily, and, if anæsthesia is profound, this occurs without the patient's knowledge. In many cases, however, the functions of the bowels are quite undisturbed throughout the entire course of the disease. Even when voluntary evacuations are completely lost, the action of the bowels may sometimes be stimulated by reflex means, as by the passage of a catheter into the bladder, the irritation of the perineum, etc.

The cutaneous and tendon reflexes vary according to the exact site of the disease. Trophic symptoms are not an important feature in myelitis, apart from the atrophy of muscles seen in inflammation of the anterior horns of the cervical and lumbar enlargements. They are observed most frequently in the integument. Vesicular eruptions sometimes appear upon the paralyzed parts, and there may also be excessive desquamation of the outer layers of the skin. The formation of bed-sores, which sometimes occurs at such an early period as to indicate their trophic origin, will be considered later. We may also call attention to the fact that the changes in the urine, which are so common in this disease, are regarded by some writers as the result of trophic changes in the secreting structures of the kidneys.

Enlargement and tenderness of the knee-joints, sometimes attended with distinct effusion, occur rarely, and their interpretation is obscure. We have also found a similar "rheumatoid" condition in the ankle-joints in a few cases of myelitis.

Gowers reports a remarkable case of trophic disturbance in a patient suffering from subacute myelitis, in which the myelitic symptoms were complicated by cellulitis of the lower part of the abdomen. At the autopsy no local cause of the cellulitis could be discovered.

Vaso-motor symptoms are more frequent than the trophic changes, but possess little clinical importance. The temperature of the paralyzed parts is often changed. At first it is sometimes increased, but later, as a rule, it is decidedly lower than that of other parts of the body. Pitting of the limbs from slight subcutaneous œdema is also not infrequent.

The disease may be arrested at any period during its course, and may then sometimes slowly go on to complete recovery. This is possible even after all the limbs are completely paralyzed, and after extreme wasting of muscles has taken place. As a general thing, however, recovery is incomplete. In the majority of cases advance is made to a certain point, and then a standstill takes place at which the patient remains for years. In some of these cases, however, further improvement is possible even after a long interval, during which the patient has remained in statu quo. In the majority of instances, however, the non-fatal cases terminate in the condition known as spastic paraplegia. The lower limbs gradually become more and more rigid, until finally each limb is moved as if it were one solid body. The feet cannot be flexed, the toes are shuffled across the floor, and the pelvis must be raised further from the ground, in order to prevent the toes from catching in the floor. The limbs offer a decided resistance to passive motion. The tendon reflexes are often enormously increased. Ankle clonus often develops spontaneously if the patient, while sitting down, happens to bear his weight on the front part of the foot.

In much rarer cases the limbs become contractured in flexion, the thighs upon the abdomen, the legs on the thighs, the feet on the legs. At the same time the thighs are usually adducted strongly upon one another, so that one thigh is drawn forcibly across the other. In these cases bed-sores are very apt to develop at the points at which the limbs come constantly in contact with one another. The patients very often suffer from intense pains in the contractured limbs, especially when an attempt is made to overcome the contracture. At other times the pains come on spontaneously in violent paroxysms, which are usually very difficult to control.

Death occurs generally from extension of the inflammation upward and implication of the muscles of respiration; from gradual exhaustion, resulting usually from the formation of bed-sores; or from disease of the kidneys consequent upon cystitis following paralysis of the bladder.

Bed-sores develop over the sacrum, and are caused not alone by the protracted pressure on this part of the body, but also by soiling from urine and fæces, which is prevented with difficulty in many cases. In certain severe cases of inflammation of the lumbar enlargement they may occur at a very early period and then seem to be due directly to trophic changes in the skin.

With proper care and treatment the bed-sores may remain confined to the integument, but not infrequently they extend more deeply, spread to the bones, and give rise to pyæmia; or, as we have also seen, the inflammation extends through the sacral foramina, and sets up a rapidly fatal meningitis.

The occurrence of cystitis is also an important symptom. Perhaps in the majority of cases it results from the introduction of foul catheters, but it may also develop when such a cause cannot be discovered. The danger in this condition consists in the secondary development of acute interstitial nephritis as the result of the introduction of bacteria along the ureter from the decomposing urine in the bladder. This complication usually proves rapidly fatal, but the writer has seen a few cases in which the post-mortem appearances warranted the belief that the morbid condition in the kidneys may subside. In such cases, however, death was the result of another attack of the same kind. But on the whole, the renal affection seems to be a rare cause of death, even if the cystitis remains unchanged for a long time.

Close study of the symptoms enables us to localize the lesion very accurately in cases of transverse myelitis.

In myelitis of the lower part of the lumbar enlargement the motor paralysis is confined to the muscles supplied by the sciatic (gluteal region, posterior thigh group, and all the leg muscles, with the exception of the tibialis anticus). The sensory disturbances (complete or incomplete anæsthesia) extend over the entire lower limbs, with the exception of the parts supplied by the obturator and crural nerves (anterior and inner portion of thigh). Reflex movements in the paralyzed parts are abolished. The sphincter ani is paralyzed. When the lesion is a severe one the paralyzed muscles undergo atrophy, and degeneration reaction is observed.

In a lesion of the upper part of the lumbar enlargement the motor and sensory paralysis involves the lower limbs completely.

In a lesion of the dorsal cord, more or less complete motor and sensory paralysis is observed in the lower limbs throughout, the anæsthesia extending upward to the intercostal nerves given off at the site of the lesion. The bladder and rectum are paralyzed. The muscles undergo very little or no atrophy, and the electrical reactions are unchanged. The cutaneous and tendon reflexes are increased on account of the abolition of the inhibitory influence from the brain.

In a complete transverse lesion of the cervical cord the paralysis affects all the limbs; when the transverse lesion does not cut across the entire cord the paralysis may be confined to the upper limbs (cervical paraplegia). The muscles of the trunk are also involved in these cases and this process is a great source of danger to life on account of the resulting interference with respiration. In lesions of the lower part of the cervical enlargement the intercostals are paralyzed. If the lesion extends higher the diaphragm also becomes paralyzed, from implication of the nucleus of the phrenic nerves. As a general thing the muscles do not undergo atrophy, because the disease usually proves rapidly fatal. When the cilio-spinal centre is involved we may observe dilatation or contraction of the pupil, according as the centre in question is irritated or paralyzed.

Optic neuritis has also been observed in rare cases of myelitis of other parts of the cord (usually of the disseminated variety), but its relation to the spinal inflammation is not clear. The neuritis and myelitis probably are effects of the same underlying cause.

In lesions of the upper cervical cord the symptoms are similar to those just described, except that they are better marked; but in these cases the disease is apt to spread into the medulla oblongata, and to involve certain of the cerebral nerves. The following brief abstract will illustrate the history of acute myelitis of the upper cervical cord, extending into the medulla oblongata.

A. B—— contracted syphilis two months ago. At the present time he presents a roseola, and is suffering from slight sore throat. On November 12th he had sexual intercourse while standing. During the same night he complained of an uneasy feeling in the legs, and of slight numbness in the tips of both middle fingers and in the feet. On the next day he walked up five flights of stairs twice, then the legs began to feel heavy. He managed to get about his room on the following day (Saturday), but on Sunday morning was unable to rise from bed. At my first visit (November 16th, 6 P.M.) I found the patient in the following condition: Almost complete paralysis of the lower limbs; slight motion of the thighs; a little reflex action from the soles; numbness of the entire limbs. He could hold his water, but after it began to flow was unable to check it. Very marked paralysis of the upper limbs, especially the right limb, but most movements could be performed slowly; partial anæsthesia of the upper limbs and trunk, none of the face; voice a trifle hoarse; temperature normal; respirations, 16; pulse, 84 and of good quality. The patient does not use the diaphragm in breathing, but can do so quite well voluntarily. He says that he sometimes has difficulty in breathing, and can't cough as well as yesterday.

November 17th, 9 A.M.—Passed a bad night, unable to sleep at all; whenever he was about to doze off had to struggle for breath; had one bad attack of dyspnœa which lasted three hours. No reflex from the soles of the feet; power absolutely lost in lower limbs; also worse in upper limbs, particularly the right; sensation more blunted; passed a large quantity of urine at 5 A.M. Respiration, 20; pulse, 90; respirations interrupted occasionally by a long breath; more difficulty in breathing; still moves the diaphragm voluntarily, but not so vigorously as last night. Speech is more hoarse, the vowels are not enunciated very clearly. Slight anæsthesia of the left side of the face, paresis of the left internal rectus, also of the right side of the face. He has double vision over a small area a little to the left of the median line on the horizontal. All the right facial muscles are paretic; he is unable to close the right eye entirely.

November 17th, 8 P.M.—Condition unchanged, has slept at intervals, once for half an hour at a stretch.

November 18th, 10 A.M.—Left pupil slightly dilated, but reacts to light; left side of face not so numb; paresis of internal rectus improved; no double vision; enunciates vowels more distinctly. Paralysis of the limbs is a little more marked; no reflex from soles; urine passed freely. During the night had severe pain between the shoulders; respiration, 22; pulse, 86; diaphragm not so active, but respiration easy.

November 18th, 9 P.M.—Respiration, 33, and more labored; diaphragm weaker; pulse, 84 and weaker. Skin cool and covered with cold sweat; looks a little bluish; face flushed; patient looks excited and talks a good deal —says "he is off his nut because he has taken too much brandy;" pupils normal; speech more difficult, vowels less distinct; does not swallow so well. The patient died at five o'clock the following morning, after increasing difficulty in breathing.

Varieties.—Very little need be added with regard to the special forms of myelitis after our detailed account of the history of transverse lesions.

Westphal's disseminated myelitis, in which the inflammation appears in scattered foci, separated by healthy tissue, has not been studied very thoroughly. The symptoms generally begin less brusquely, and, unless several foci of inflammation are closely approximated to one another so that the cord is practically cut across by the lesion, they point distinctly to a focal lesion. For example, a small focus in the cervical enlargement may cause paralysis of one arm, perhaps of the leg on the same side; while another focus in the lumbar enlargement may cause paralysis of one or both legs, etc. Much depends in such cases on the close observation of the sequence of symptoms and on the etiology (chiefly acute infectious diseases and syphilis). It must be confessed, however, that the literature of disseminated myelitis is very scanty, and that most of our knowledge concerning it is purely hypothetical.

Compression myelitis is the term applied to inflammation of the spinal cord secondary to compressing lesions outside of the cord (caries, cancer, or exostoses of the vertebræ, erosion of vertebræ, and pressure of an aneurism), or to tumors of the cord itself, which give rise to compression of adjacent parts. This form of myelitis is usually very slow in its onset, but inasmuch as some cases begin abruptly, we will devote a little attention to it under the heading of acute myelitis.

It would be a mistake, however, to regard all cases usually included under this head as really the result of compression. In Pott's disease, for example, we find, as a rule, that the disease of the bone has given rise to peripachymeningitis, and also to pachymeningitis which, together with the narrowing of the canal incident to the displacement of the vertebræ, causes compression of the cord and secondary inflammation. But in not a few cases of Pott's paraplegia we find that the vertebral displacement has occurred in such a way that compression of the cord is not produced, and that the amount of meningeal thickening is too slight to produce compression. In such cases we may attribute the myelitis to the direct irritation of the cord by the products of meningeal inflammation.

In the majority of cases compression-myelitis is the result of Pott's disease, and the lesion is situated in the dorsal region. In this condition the disease is often preceded by symptoms of irritation of the roots of the nerves by the diseased bone or membranes, consisting of a cincture feeling around the abdomen and chest, or pains in the legs; sometimes there is an eruption of herpes zoster upon the trunk or lower limbs. It is a peculiar feature of this condition that the occurrence of paralysis may be preceded for quite a while by a marked exaggeration of the knee jerk and ankle clonus. In the same way, these symptoms may persist for a long time after the recovery of motor power.

After the motor paralysis has developed, the symptoms differ in no respect from those of ordinary transverse myelitis, except that there is usually a much greater discrepancy between motor and sensory paralysis, the latter being very often entirely absent. The paralysis exhibits very little tendency to extend beyond the parts originally involved. In a certain proportion of cases the lower limbs become contractured—the thighs flexed on the abdomen, the legs on the thighs—or shooting pains in the lower limbs become a prominent feature of the disease. To judge from his own experience, the writer is inclined to believe that this condition is particularly apt to develop when the myelitis is the result of irritation of the cord rather than of compression by morbid products.

When the compression myelitis is the result of cancer of the vertebræ, pains in the lower limbs and trunk are extremely distressing, and if cutaneous sensation is abolished at the same time, the condition is known as anæsthesia dolorosa. Apart from the excessive violence of the pains, this paraplegia dolorosa cannot be distinguished from other forms of compression myelitis.

Diffuse central myelitis is another rare variety of the disease, in which the lesion is confined chiefly to the central gray matter of the cord. It generally begins very suddenly with anæsthesia and loss of power in the lower limbs. The evidences of a severe cord lesion soon become manifest. The motor paralysis rapidly becomes complete, the cutaneous reflexes and the knee jerk are soon lost, the muscles undergo rapid atrophy and present degeneration reaction at an early period. The bladder is paralyzed from the start, and ugly bed-sores soon form over the sacrum. Then the paralysis and anæsthesia rapidly extend upward, involving the intercostal muscles and upper limbs. Finally, the muscles of deglutition and the diaphragm are attacked, and speedy death ensues. The entire course of the disease, indeed, presents a picture of malignancy which is rarely found in other forms of myelitis. In rare cases the acute symptoms subside and the disease passes into a chronic stage, but a certain degree of doubt attaches to the diagnosis in cases which do not terminate fatally.

In concluding the clinical history of myelitis we will refer briefly to a mode of termination which has been unnoticed by the majority of writers. In a number of cases which have come under our observation the disease appeared to begin as a transverse myelitis; but the symptoms cleared up in great part, and then merged into those of locomotor ataxia or multiple sclerosis. In the following case—by no means the most striking one—we were fortunate enough to obtain a post-mortem examination.

J. D——, thirty-five years of age, married; entered Randall's Island Hospital on September 4, 1883. The patient gives no evidence of syphilis; habits regular.

The present illness has lasted nine months; it began with ptosis of the right eye; shortly afterward he began to have shooting pains in the legs and arms. In a few weeks he had to quit work on account of the pains and weakness in the lower limbs. About five months ago the patient got so weak that he was unable to walk, and had trouble in holding his water.

Present condition (October 4, 1883).—Patient walks with assistance, but has a characteristic heel gait, and must watch the movements of his feet; he reels to and fro when standing with the eyes closed.

Anæsthesia and analgesia are present below Scarpa's triangle in both thighs and legs; patellar reflexes absent. Slight inco-ordination of upper limbs, and some numbness of the fingers. Partial ptosis of right eye; both pupils very much dilated, and react poorly to light; optic papillæ unchanged; special senses normal. The dynamometer is forced to forty by the right hand, to thirty-six by the left hand.

October 24th.—Had a pulmonary hæmorrhage; dulness and a few moist râles over the upper lobe of left lung.

The motor power of the lower limbs improved considerably, but the incoördination rapidly grew worse, the limbs jerking in every direction when any voluntary movement was attempted. There was very marked emaciation, but the muscular power finally appeared to be normal compared with the amount of muscular tissue retained. The pains disappeared almost entirely; sight remained normal. The phthisis continued to advance, and the patient died January 7, 1886, without the development of any fresh symptoms on the part of the nervous system.

Microscopic examination of the spinal cord showed complete sclerosis of the posterior columns (enormous increase of the neuroglia and of nuclei), together with a general increase of connective-tissue elements in the remaining portions of the cord, with the exception of the gray matter, which seemed to be perfectly normal. In addition, the blood-vessels of the posterior columns were very much dilated, and their walls were exceedingly thickened, particularly the adventitia, in which the nuclei were enormously increased. The nuclei around the central canal were increased in number, and there seemed to be, also, an increase of fibrous tissue in this locality. Here and there in the other columns of the cord were seen blood-vessels which also presented a considerable increase of nuclei.

PATHOLOGICAL ANATOMY.—In a good many cases of acute myelitis no change in the structure of the cord is visible to the naked eye. Sometimes the diseased parts are softened, and their color is changed. The cord cuts less firmly than in the normal state, the cut surface projects as if the cord were too large for the enveloping pia mater, and the normal differentiation between the white and gray matter becomes less distinct or is entirely effaced. The entire surface has a reddish tinge, sharply defined reddish streaks (distended blood-vessels) are often seen, particularly in the white matter; and here and there we occasionally notice minute red specks (capillary hæmorrhages). In some cases these hæmorrhages form the most marked change to the naked eye, and the cut surface has a bright red, or, at a later stage, chocolate color (hæmorrhagic myelitis). The degree of softening varies between very wide limits. In some cases it is entirely absent, in others it is so pronounced that the diseased part of the cord, but particularly the gray matter, is diffluent and flows out like cream.

Microscopic examination is usually necessary in order to be certain of the presence of myelitis. It is still a mooted question whether the changes begin in the blood-vessels or in the parenchymatous tissues of the cord, but it is more than probable that the primary changes occur in the vessels.

The blood-vessels (small arteries, veins, and capillaries) are distended with blood, the walls increased in thickness, and the nuclei have undergone proliferation. White and red blood-corpuscles are found in abundance within the sheaths of the vessels and the adjacent parts of the nervous tissues. The cellular elements of the neuroglia are also increased in size, and are much more numerous than usual. In addition, granular fatty cells are found in great numbers. These cells often contain one or more drops of myelin, and are the result of fatty degeneration of white blood-globules, which may or may not absorb myelin. They are not characteristic of myelitis, but are also found in softening from any cause. It is probable that the neuroglia cells, when they undergo proliferation, also take part in the production of these granular corpuscles. The granulo-fibrillar part of the neuroglia also undergoes proliferation, and becomes much more prominent than in the normal state.

The most important changes are found in the nerve-fibres and ganglion-cells. The medullary substance of the former coagulates into clumps of varying size, which gradually become smaller and smaller, and are finally converted into fatty granules. The most common change in the axis-cylinders consists of dilatation, which sometimes assumes enormous proportions, but is not distributed uniformly over the entire length of the fibre. In addition, the axis-cylinder loses the faint striation which it originally possesses, and in severe cases it finally undergoes complete disintegration.

The first change noticed in the ganglion-cells is the increasing homogeneity of their finely granular contents, which is always associated with some change in chemical constitution, as shown by the fact that they stain less readily with coloring reagents. The cell contents assume more of a yellowish, blurred look, the processes seem to retract and become thicker, the cell becomes rounded, and the nucleus grows more indistinct. Finally, the cell may shrivel up and be converted into a small shapeless mass, which usually contains an excess of pigment. Vacuoles are often found in the cells, but doubt has been cast upon the ante-mortem development of this condition. The corpora amylacea are often increased very much in number, but this is not characteristic of inflammation.

The majority of authors are agreed that severe inflammatory changes cannot be recovered from. This does not seem to be in accord with the writer's experience, that almost complete recovery may occur in certain cases in which the clinical history has pointed indubitably to a very severe and extensive inflammation of the spinal cord.

In extremely rare cases acute myelitis terminates in the formation of one or more small abscesses in the cord. The usual termination is by the development of an excessive amount of neuroglia tissue. The development of cysts as the result of absorption of the fluidified nervous structure is also a rare termination.

With regard to the secondary degenerations of the cord which are found after myelitis, we refer to page [illegible], Vol. VI.

Diagnosis.—Acute myelitis must be distinguished from meningitis. The latter affection is very much rarer, apart from those cases in which it is associated with inflammation of the cerebral pia mater, than acute myelitis. In the former the pains in the back and limbs, the cramps in the muscles, and hyperæsthesia are much more marked than in myelitis, and usually persist for a much longer time. Paralytic symptoms are not well marked, and the bladder and rectum, as a rule, are unaffected. In myelitis, on the other hand, the initial irritative symptoms are often entirely absent, or, in the very large majority of cases, soon give place to anæsthesia and motor paralysis. With the exception of certain cases of inflammation of the cervical cord, fever is usually absent or slight in myelitis; in meningitis there may be decided febrile movement.

In two cases we have seen acute myelitis mistaken for acute articular rheumatism—once in a child suffering from compression myelitis of Pott's disease, another time in an adult with extremely acute dorsal myelitis. In both patients the joints of the lower limbs were very tender on pressure, and in the adult there was high fever. In the former, however, examination of the spine revealed a well-marked kyphosis, the loss of power was disproportionate to the apparent severity of the pain, and the tendon reflexes were greatly exaggerated. In the latter the patient also suffered from rapid pulmonary phthisis, which explained the high fever; the pains were not confined to the joints, but were also marked in the muscles, and the lower limbs were anæsthetic (anæsthesia dolorosa).

Hysteria is sometimes mistaken for myelitis, especially when it occurs in young females, or *vice versa*, myelitis is sometimes, though less frequently, regarded as hysterical paraplegia. The occurrence of other undoubted evidences of hysteria is an important point in diagnosis, but too much stress should not be laid upon this feature, since it must be remembered that hysterical individuals are also liable to be attacked by myelitis. The etiology should also be taken into consideration, and in the absence of any of the causes previously mentioned, the diagnosis of myelitis in a young female should be looked upon with suspicion. In hysterical cases, however, the evidences of serious organic lesions of the cord are always wanting. There is no pronounced wasting of muscles, no change in their electrical excitability, no loss of power of the bladder and rectum. On careful observation, moreover, it is often found that the apparent paralysis varies in different positions of the body, and that there are sudden changes in motility which remain inexplicable on the theory of an organic disease of the cord.

The diagnosis from hæmorrhage of the cord is usually easy, except in cases of hæmorrhagic or apoplectiform myelitis, when the symptoms have come on with extreme rapidity. Hæmorrhage into the spinal cord is extremely rare, except as the result of injury. The symptoms of motor paralysis attain their utmost severity at once, and then, unless the hæmorrhage is situated high in the cervical region, begin to improve slowly up to a certain point. With the exception of the suddenness of the onset, and the previous occurrence of traumatism, there is really no means of differentiating spinal hæmorrhage from acute myelitis. In the majority of cases, indeed, the hæmorrhage is followed by myelitis, either as the result of the injury to the elements of the cord from the traumatism, or of the irritation excited by the clot.

Acute central myelitis is sometimes distinguished with difficulty from Landry's paralysis. In the latter disease, whose pathological anatomy is unknown, sensory symptoms are unimportant, or may be entirely absent. The motor paralysis begins in the lower limbs, but extends in a few days to the upper limbs, and then to the centres for respiration and deglutition, the disease rarely lasting more than from one to two weeks before terminating fatally. The electrical irritability of the paralyzed muscles is usually normal, but in certain doubtful cases diminution of faradic excitability has been reported. The functions of the bladder and rectum are usually undisturbed. It seems probable, from the histories of recently reported cases, that enlargement of the spleen is quite a constant feature of the disease. But despite these numerous points of difference between this disease and myelitis, the question of diagnosis will sometimes remain doubtful in those cases which terminate in recovery.

After the diagnosis of myelitis has been made, the question may arise, Is the spinal inflammation due to pressure? This is not always easy to answer. In the majority of cases of compression myelitis the primary lesion is caries of the vertebræ, and, as a general thing, the deformity of the spine is so pronounced that there can be very little doubt with regard to the diagnosis. In Pott's paraplegia, moreover, the exaggeration of the cutaneous and tendon reflexes is an important sign which may precede other symptoms for a considerable period, and may persist after other evidences of myelitis have disappeared. In addition, the sensory symptoms are usually much less pronounced than those in the motor sphere, and may even be entirely absent, despite complete paralysis of the limbs. In a few cases, however, particularly when the patient has been confined to bed on account of some other disease, spinal deformity may not be noticed, and the myelitis is then apt to be regarded as primary.

When compression-myelitis is secondary to cancer of the vertebræ, the recognition of the nature of the primary disease usually depends on the presence of a primary cancer in some other part of the body, on the violence of the pains in the paralyzed parts (especially if associated with anæsthesia), and the presence of a deformity of the spine which seems to be due to an irregular enlargement of the vertebral arches or lateral masses. It must not be forgotten, however, that cancer of other parts of the body may be associated with ordinary vertebral caries. In a case of this kind recently under my observation, I made the diagnosis of compression-myelitis from vertebral cancer, but the autopsy proved that the disease had been an ordinary Pott's paraplegia.

The diagnosis of the localization of the inflammation in the cord depends upon the grouping of symptoms, for which we refer the reader to the section on clinical history.

Prognosis.—Complete recovery from acute myelitis, with the exception of the compression-myelitis of Pott's disease, is a comparatively rare result. Incomplete recovery is by far the most frequent termination, although a fatal result is by no means uncommon. Other things being equal, the disease is more apt to terminate fatally, the higher the location of the lesion in the cord. If the centre for the phrenic nerve has been attacked, as shown by paralysis of the diaphragm, recovery is extremely rare. The occurrence of bed-sores is likewise of grave import, particularly if they develop at an early period. When they occur after the disease has lasted a long time, they often heal quite rapidly under suitable treatment. Mild cystitis is so common in myelitis that it can hardly be regarded as aggravating the prognosis, but in severe cases, especially if the bladder is completely paralyzed, there is always danger of the production of acute interstitial nephritis. The latter affection is almost inevitably fatal at an early period, though, in some cases, it seems to pass into a stage of quiescence.

The prognosis as regards recovery is also so much the more impaired the greater the degree of implication of the gray matter, as evidenced by rapid atrophy of the paralyzed muscles and degeneration reaction in these parts. But it must also be remembered that even the most marked atrophy of the muscles, and complete abolition of their electrical irritability, does not entirely preclude the possibility of a very satisfactory degree of recovery. I have had under observation a patient in whom the limbs were completely paralyzed, and wasted to the extreme, and degeneration reaction was present except in those muscles in which no reaction could be obtained (even the intercostals were partly paralyzed); and yet this patient, at the end of a year and a half, was able to walk about and to perform her duties in such a satisfactory manner that she requested her discharge from the hospital.

The occurrence of a spastic condition of the lower limbs constitutes an almost insuperable obstacle to any further improvement. The degree of motor power which is acquired in these cases, however, is usually quite considerable, and the patients are often able to move about quite freely, unless the rigidity of the limbs is excessive.

Pott's paraplegia generally offers a favorable prognosis, unless the vertebral caries itself, or its sequelæ, constitutes a serious menace to life. Improvement in apparently hopeless cases sometimes comes on quite suddenly, and the patient may recover even from a number of severe attacks. In these cases there is always danger of a relapse so long as the tendon reflexes remain exaggerated.

Treatment.—In order to avoid repetition this subject will be considered in connection with the treatment of chronic myelitis.

CHRONIC MYELITIS.—*Etiology.*—Chronic myelitis is a much rarer affection than the acute or subacute form of the disease. It is well to bear in mind that the term should not be applied to those cases in which a chronic condition of paraplegia is left over as a sequel of acute myelitis. The use of the term is justifiable only when the disease begins in a slow and insidious manner.

The causes of chronic myelitis are similar to those of the acute form. It is generally held that the difference in the mode of beginning is the result of differences in the intensity of the etiological factors—for example, sudden and violent exposure will produce acute myelitis, long continued and less severe exposure will produce chronic myelitis—but it seems to me that this view is based on theory rather than on well-established clinical facts. In traumatic cases a single traumatism may set up an inflammation of the cord which does not make its appearance until long after the symptoms of the original injury have subsided. Perhaps there has been some spinal pain for a few days or weeks after the injury, then the patient feels entirely well; but a few months later the signs of slowly advancing myelitis make their appearance.

Syphilis seems to exert a considerable influence as a predisposing cause, but it is questionable whether it acts by simply making the spinal tissues more vulnerable or by the production of gross lesions in the vessels or mem-tissues of the cord. It seems probable, however, that in a large proportion of such cases the former theory is correct, the syphilitic virus appearing to act as a potent predisposing factor, as it does in the production of locomotor ataxia.

Alcoholism also appears to exert a great influence in the production of chronic myelitis; but we must bear in mind that this vice is often connected with repeated exposure to cold and wet, and to violence, and that it is difficult to decide between the parts played by each of these factors.

Symptoms.—The symptoms of chronic myelitis are very similar to those of the acute form, except that they develop more slowly and insidiously. In some instances this gradual course may be interrupted occasionally by more or less acute exacerbations. In the majority of cases the disease affects the dorsal region, and hence the symptoms are those of slowly developing paraplegia. As in the acute form, the sensory symptoms are generally much less marked than the motor phenomena. The patient complains of formication and tingling in the feet, or a sense of numbness in the soles, so that the floor does not feel natural in walking. This condition may last a very long time, although no change in sensation can be noticed objectively after the most careful examination. Pain is not a prominent feature, although there is often complaint of a slight girdle feeling around the abdomen. Slight dull pains are often felt in the back and limbs, particularly after walking for some length of time. These symptoms may last a long time before any motor weakness becomes apparent. The patient notices that he becomes more tired than usual after walking, and finally begins to drag the legs. Rigidity of the lower limbs is an early and almost constant accompaniment of the loss of power (spastic paraplegia). In many cases, indeed, we have noticed a marked development of this spastic condition before any real loss of power could be detected. At the same time the tendon reflexes are notably increased. In some cases disturbances of sensation, which can be determined by objective examination, may be entirely absent, and subjective sensory disturbances may also be extremely slight, or wanting. The symptoms are then exactly similar to those of so-called primary lateral sclerosis, and may remain in this stage for several years before the advent of other symptoms attests the spread of the disease.

In a very small proportion of cases, particularly in those which are due to syphilis, the lesion is confined to a small section of the cord, and, if limited to one-half, may give rise to the symptoms of spinal hemiplegia (paralysis of motion on one side, paralysis of sensation on the opposite side). As a general thing, however, the lesion is not confined exactly to one-half of the cord, but extends somewhat into the other side, and motor and sensory symptoms are therefore observed in each limb, although the paralysis of motion is more marked in one, that of sensation in the other. In this form of the disease, sensory symptoms (anæsthesia, pains in the back and limbs) usually form an important feature.

As a general thing, the lesion slowly spreads along the cord in an upward or downward direction (usually the former), and other parts of the body become involved. The spread of the disease may be exceedingly slow, and even twenty or thirty years may elapse before the final termination. In other cases the chronic course may be interrupted by acute exacerbations. We have also seen several cases in which the symptoms of chronic myelitis appeared to merge later into those of posterior sclerosis or multiple spinal sclerosis.

Pathological Anatomy.—The pia mater over affected parts of the cord is often thickened and opaque, and more firmly adherent to the underlying structures. In many cases the cord itself may appear unchanged, but usually the myelitic portions are firm to the feel, show greater resistance on cutting than adjacent parts, and have a distinctly gray color. Here and there enlarged vessels are sometimes discernible. In rare cases we find cavities in the cord (syringomyelia), the origin of which is still a matter of discussion. The most generally accepted theory at the present time is that of the origin of the cavities in a gliomatous new formation. Joffroy and Achard, however, have recently written an excellent article in which they maintain, with great ability, the origin of these cavities as a result of chronic myelitis. The following is a brief summary of their views: The cavities are of varying size and shape, are situated chiefly in the cervical and dorsal regions, and almost exclusively in the gray matter, particularly of the posterior horns. They are not due to dilatation of the central canal, which is unchanged in some cases. The lesion may affect one or both sides of the cord; the surrounding tissues may be very slightly involved. A cavity sometimes occupies the centre of a focus of myelitis, which extends by preference into the lateral columns. Chronic inflammation of the pia mater may also be present. The writers believe that the disease is due to chronic myelitis, because at the upper and lower limits of the cavernous lesion the appearances are simply those of diffuse sclerosis, situated generally near the central canal. The cavities are due to the fact that the vessels in the focus of inflammation are obliterated by thickening of their walls or by thrombosis, and the resulting necrotic substance is absorbed.

The microscopical appearances are very similar to those left over after acute myelitis has passed into the chronic stage. The changes in the interstitial tissue are particularly noteworthy. The granular condition of the neuroglia is lost, and in its stead we find a fibrillated tissue, containing an unusually large number of neuroglia cells and round cells. The blood-vessels are usually very much dilated, their walls decidedly thickened, and their nuclei increased in number. The sheaths of the vessels are apt to contain broken-down white and red blood globules, pigment, and fat granules.

The axis-cylinders are found to vary greatly in size; some of them are remarkably large, others are very decidedly atrophied, and have lost their medullary sheath. The ganglion cells contain an increased amount of pigment, are diminished in size, and often destitute of processes, and many of them are converted into shapeless masses in which no definite structure is distinguishable.

Diagnosis.—The diagnosis of chronic myelitis is usually a comparatively easy matter, and is almost always tantamount to the recognition of a slowly developing paraplegia. It is not so apt as acute myelitis to be mistaken for hysterical paraplegia, because the latter disease usually begins much more abruptly than chronic myelitis, which may advance slowly for years. The frequent occurrence of changes in the electrical excitability of the muscles in chronic myelitis is also a distinctive feature.

Railway-spine, when due to chronic myelitis or meningo-myelitis, may prove a source of great difficulty in diagnosis, especially because the element of malingering so often comes into play in this condition. When this factor can be excluded, the diagnosis is based on the slow development of symptoms, at a variable period after the injury, which point to disseminated focal lesions of the cord: irregularly distributed paralyses, various paræsthesiæ, pain in the spine and limbs, disturbances of micturition, localized atrophies of muscles. A depressed and irritable condition of the mental faculties, with loss of memory, is quite common in this condition.

The diagnosis of chronic compression myelitis is made in the same way as that of the acute form, except that the symptoms develop much more slowly. Acute exacerbations are particularly apt to develop in this form of the disease.

Chronic myelitis can only be distinguished from the persistent paraplegia left over after an acute attack, by the history of the onset of the illness. When, for any reason, the patient is unable to furnish the previous history, the diagnosis is impossible.

Tumors of the spinal cord or its membranes are rare, and their differential diagnosis from chronic myelitis is extremely difficult. The clinical history of the former consists essentially of symptoms of irritation of the nerve roots, followed by those of compression of the cord. In some cases, however, the latter precede the former. The compression of the nerve-roots sometimes lasts for years before the evidences of compression of the cord make their appearance. Probably the most important point in the differential diagnosis is the great variation in the severity of the symptoms which is sometimes noticed. In addition, it is found not infrequently that the first evidences of compression of the cord occur in the form of spinal hemiplegia, owing to the fact that the tumor often develops first in one lateral half of the cord.

Prognosis.—The prognosis of chronic myelitis is always grave. Even chronic compression myelitis, which presents the most favorable prospects among the different forms of the disease, rarely terminates in recovery. Unless the slow course of the spinal inflammation is interrupted by acute exacerbations, the patient may linger for years. The longest lease of life is enjoyed in those cases of transverse myelitis in which the disease does not extend up the cord. The greatest danger in these cases arises from the development of cystitis and secondary interstitial nephritis.

In the syphilitic forms of chronic myelitis we are sometimes able to secure a fair degree of recovery, especially if treatment is begun before the disease has extended across the entire section of the cord. But even here it will be found that complete recovery is rarely practicable.

It is held by many writers that cases of railway-spine, which, as we have stated, is probably due to chronic myelitis and meningo-myelitis, usually recover; but this statement does not agree with the experience of the majority of unbiassed observers.

Treatment.—The treatment of acute and chronic myelitis will be considered under this heading, because the treatment of the latter form is similar to that of the sequelæ of acute myelitis.

The most important indication is to secure as absolute rest in bed as is possible under the circumstances. As soon as any symptoms make their appearance which suggest the onset of myelitis, the patient should take to bed and remain in the recumbent position. The wants of nature should be attended to with the aid of the bed-pan, in order to avoid, as much as possible, movement during the acts of urination and defecation. This is, in our eyes, by far the most important remedial agent at our command. It is often difficult to determine at what period it is best to allow the patient to begin to exercise the paralyzed limbs, but it is always better to err on the safe side. We have seen very marked improvement in a number of apparently hopeless cases, in which this plan had been faithfully carried out for a year to a year and a half.

Contracture of the tendo Achillis is a very common sequel of all forms of myelitis, and it has been suggested to me by one of my colleagues that the pressure of the bedclothes upon the feet may exercise some influence in the production of this unfortunate symptom. In order to obviate this, the bedclothes may be suspended on a barrel hoop placed across the lower part of the bed. But the contracture will develop, despite this precaution, in a considerable number of cases.

Next to rest, cleanliness is all-important, because its neglect is very apt to result in the production of bed-sores. This usually necessitates the most careful nursing. The external genitalia and gluteal regions must be frequently washed, and thoroughly but gently dried. At the slightest indication of the development of a bed-sore, an air-ring should be placed under the buttocks, care being taken that the joints of the ring are not sharp. If the evidences of dermatitis are not relieved speedily in this way, the patient should be placed on a water-bed. When a bed-sore has formed, we know of no better treatment than Brown-Séquard's method of application of cracked ice followed by a flaxseed poultice. This may be followed by dusting with iodoform, or, if the sore is too large, the application of a simple carbolated ointment.

The bladder must be carefully looked after. If the patient can urinate in the prone position, even after considerable effort, he should be encouraged to do so, in order to obviate the necessity of catheterization. But the latter must be resorted to at once, as soon as the bladder is no longer thoroughly emptied. The greatest precautions must be taken to keep the catheter thoroughly antiseptic in order to prevent the introduction of germs. Even a soft rubber catheter must be introduced very gently, inasmuch as the mucous membrane of the bladder is very apt to be congested, and bleeds readily under such conditions.

Counter-irritation is useful in very many cases. During the first stages of an acute myelitis the application of dry cups along the spinal column may be attended with some benefit. Vigorous counter-irritation with fly-blisters is indicated at a later period, but these do not promise much improvement after the disease has become stationary. In this connection we may mention that in a case of chronic myelitis in which all hope of recovery had long been abandoned, we noticed a remarkable degree of permanent improvement follow the development of a large carbuncle of the back.

The actual cautery is also recommended. We have never seen any benefit from its use, except in rare cases of compression myelitis. In such cases, however, it sometimes acts with remarkable rapidity.

Among other non-medicinal agents may be mentioned baths and electricity.

As a rule, the patient cannot tolerate extremes of temperature. We usually recommend a sitz-bath at a temperature of 100° to 110° F., in which the patient remains for from fifteen minutes to half an hour. If spastic phenomena are well marked, the bath may be as hot as can be borne by the patient. When the spastic phenomena are not prominent the patient may receive a full bath at a somewhat lower temperature. It is well in such cases to follow the bath with rubbing and massage.

Electricity, when faithfully and persistently applied, is often productive of excellent results. It is used as a spinal current, or directly to the paralyzed or contractured parts. When applied to the spine one large electrode should be placed over the site of disease, the other on some indifferent part of the body or spine, and should be held constantly in position for from three to five minutes. The direction of the current seems to be immaterial. Much better results are obtained from applying the current directly to the paralyzed parts. In the majority of cases the galvanic current is preferable, but the faradic current may be used when the muscular contractility remains normal. The current should be merely strong enough to produce visible contraction of the paralyzed parts. The constant stabile galvanic current is used in the treatment of contractures, the electrodes being applied directly to the nerves supplying the contractured muscles. At the same time the interrupted galvanic or faradic current may be applied to the antagonists. In our own experience very little, if any, benefit has been derived from spinal galvanization; but, on the other hand, we have obtained most excellent results from the patient, persistent use of local electrization. This even holds true of cases of marked contractures of the lower limbs, but a good deal will then be gained by the electrical course combined with tenotomy of the contractured parts.

Medicinal treatment does not play a great part in the management of this disease. Ergot has been highly recommended in the acute stages, and hypodermic injections of ergotine have been employed at the onset of hæmorrhagic myelitis. We have never seen the slightest advantage from its use, and have abandoned it altogether. Iodide of potassium has also been recommended very highly, and Dr. Gibney speaks in the most favorable terms of its administration in large doses (even ʒ j.–ij., t. i. d., in children), in the compression myelitis of Pott's disease. It is very difficult to form an opinion upon the value of this agent in myelitis, but it has seemed to us to exercise a certain amount of beneficial effect. But we have employed it so faithfully, and with such little effect, in Pott's paraplegia, that we are compelled to deny any special influence in this form of the disease. Weir Mitchell has recently recommended suspension in this disease, but the value of the measure must be determined by future investigation.

The only medicinal agent which has seemed to have a decided influence in our hands is strychnine. This drug may be administered as soon as the acute symptoms have ceased to advance, and it is by no means contraindicated by the occurrence of spastic symptoms. The dose may be raised gradually from gr. $\frac{1}{60}$ to gr. $\frac{1}{20}$ t. i. d., and may be given continuously for months.

So long as any improvement is observed, the patient should be kept as quiet as possible. Later, gentle exercise may be allowed, but the patient must not be permitted to tire himself. Sexual intercourse is particularly to be avoided. Even after the condition of the patient has been stationary for a long time, benefit is sometimes derived from another course of treatment with electricity, counter-irritation, and strychnine. *Leopold Putzel.*

SPINAL CORD, SURGERY OF THE. The attention of the surgical world, already on the *qui vive* in the matter of cerebral surgery, was again instantly arrested by an important paper of Horsley and Gowers[1] in which was reported for the first time the removal of a spinal tumor. The patient was a man, forty-two years of age, who for three years had suffered a great deal beneath the left scapula, and for four months had been paraplegic. The motor and sensory paralysis extended to the base of the sixth dorsal nerve, with spasms in the legs and feet, clonus of the rectus, cystitis, and retention of the urine. On June 9, 1887, the tumor was removed and the wound healed by the first intention. The patient gradually recovered to such an extent that he was able to dance and to walk three miles with ease. This case was quickly followed by the remarkable paper of Macewen,[2] in which he records six cases in which the posterior arches of the vertebræ had been removed. Three of the cases were paraplegics from connective-tissue tumors at the angular curvature of the spine, and were completely cured by removal of the tumor. Two of the other cases succumbed—one a week after the operation, the other some months later—from general tuberculosis. The sixth case was one of paraplegia from traumatism, which was cured by opening the spinal canal, elevating the depressed arch of the twelfth dorsal vertebra, and dissecting away the connective-tissue tumor on the theca of the cord, extending from the eleventh dorsal to the second lumbar vertebra. The tumor was one-fourth inch thick. In addition to these, Macewen has evacuated an abscess in the posterior mediastinum which was exercising pressure on the heart and bronchi. The operation was completely successful. Macewen did the first of these spinal operations on May 9, 1883, and reported the case in *The Lancet*, 1885, i., 881. Since then Wright, of Manchester,[3] has reported an operation on a case of angular curvature, with temporary, but no permanent benefit. Thornburn, of Manchester, has reported two cases, in one of which[4] Mr. Jones trephined a boy for dislocation of the second lumbar vertebra, with partial paraplegia. He removed some dense cicatricial tissue. Twenty months later he could walk three miles, and was still improving. In the other case,[5] Mr. Southam trephined the third dorsal arch and evacuated some pus from an apparent idiopathic abscess outside the dura, but without success.

Mr. Keetley[6] operated unsuccessfully on a fracture of the spine with complete rupture of the cord. Rogers[7] has reported a successful case of prevertebral abscess in the dorsal region, which was evacuated by the resection of a number of ribs and the transverse process of a vertebra. Besides evacuating some pus, he removed some fragments of bone in the vertebral canal. Deaver and Lloyd[8] report a case of tumor of the cervical spine which was removed unsuccessfully. The dura was not opened, but was merely punctured by a small exploring needle, which showed it to be tougher and thicker than normal. The swelling on the side of the spine was found to be the thickened and somewhat displaced lamina of the vertebra. There was said to be some osteomyelitis.

In the *St. Louis Medical and Surgical Journal* for June, 1888, Dr. W. T. Wilkins reports a case of a child born "with a growth on its back," the mother having been severely injured the day before its birth. On operation on the day after birth, the last dorsal and first lumbar vertebræ were found separated a half inch, and a hernia protruded through the fissure. The spinal cord was pushed to one side. The hernia was reduced, the two vertebræ held together by a figure-of-8 carbolized silk ligature passing through the intervertebral notches of the two vertebræ above and below, and the child was practically well in a few days.

In the *Medical News*, December 22, 1888, Dr. Morton reports a case (in which I assisted him) in which, for fracture and dislocation of the vertebræ, he removed the laminæ and articulating processes of the first lumbar vertebra and exposed the canal. The wound was drained, sutured, and dressed antiseptically, and the patient made an excellent operative recovery, though the paraplegia is still almost total. In the same journal Dr. Roberts alludes to a case of Dr. J. W. White of removal of the posterior arches of three or four cervical vertebræ in the search for a supposed tumor. None was found, but the patient's condition bettered after the operation. Abbe[9] reports a case of tubercular tumor compressing the cord, with paraplegia. The operation gave exit to two ounces of cheesy pus. The posterior arches of the eighth, ninth, and tenth dorsal vertebræ, and a mass of dense connective tissue, were removed. The cord for nearly two inches and a half was compressed against the anterior wall of the canal. Nine weeks later he could walk with the support of a chair, and was still improving.

These, so far as I have been able to discover, are the only operations on the spine so far published, but I am aware that two or three other unpublished operations have been performed. These cases show that in angular curvature of the spine, with implication of the cord, much may be done by way of relief, and with good prospects, in not a few cases, of cure of a recent compression; that pressure on the cord from traumatism, in favorable cases, may very probably be greatly relieved; that abscesses in the posterior mediastinum or in the vertebral canal are not beyond the reach of surgical aid; that a tumor of the cord may be successfully removed, and the patient sometimes cured. Of course it is quite too early in the history of spinal surgery, as of cranial, to draw any definite conclusions, but these cases at least point out the way in which we should travel. Experience will undoubtedly demonstrate that we can do far more than has been done or hitherto dreamed of as possible. Indeed in Mr. Horsley's paper he has analyzed fifty-seven cases of tumor of the cord and has shown that eighty per cent. would probably have recovered had they been operated upon, whereas every one died, a reproach to surgery.

Operative Technique.—The following directions are derived partly from personal conversations with Mr. Horsley, and partly from the experience which I have had upon the cadaver with the aid of Dr. Wm. J. Taylor. I have as yet had no suitable case for operation upon the living subject.

The site of the operation should be thoroughly disinfected, and the same antiseptic precautions followed as advised in operations on the brain (p. 299). An ample incision should be made in the middle line. The laminæ and the transverse processes of the vertebræ should be exposed on one side, and the muscular tissue separated from them quite thoroughly, with the periosteum, so far as practicable. In doing so the deep lumbar or other fascia should be incised transversely in order to give room. Sponges should then be stuffed into the wound in order to check the bleeding by pressure, and larger vessels should be seized by hæmostatic forceps. The same procedure should then be carried out upon the opposite side of the spinous processes. An opening into the canal may now be made either by a saw or by a trephine, and afterward may be enlarged by a saw, rongeur forceps, or strong bone-forceps, as may be desired. Mr. Horsley prefers strong angular bone-forceps. On the cadaver I have found that the rongeur forceps answers very well. The trephine should not be over three-fourths of an inch in diameter, and should be placed as near the spine as possible and directed somewhat obliquely inward, in order to avoid injuring the nerves in the intervertebral foramina. It must not be forgotten that the laminæ are thin, and that the trephine penetrates them very much more rapidly than it does the skull. The ligamenta subflava will give but little trouble in the upper spine, but as we go downward they become much more developed, and are proportionately more of a hindrance in gaining access to the canal. The fatty tissue between the dura and the bone will now be exposed, and is apt to be more or less full of large veins, which in Lloyd and Deaver's case were remarkable by their absence. It is best to tear through this tissue in the middle line and to push it out of the way. Mr. Horsley tells me that this tissue is remarkably compressible, and that this squeezing it out of the way aids materially in checking the hæmorrhage. If the dura has to be opened, Horsley recommends that the anæsthesia should be very complete on account of the great sensitiveness of the posterior column. The dura should be lifted, and the opening in the middle line should be of such an extent as is necessary to afford a good view of the cord. It may be held aside by a hook or a thread, if necessary. If necessary it may be incised transversely, but if the intention is to close the dura after the operation, it is better that this should not be done. By a blunt hook or by an aneurism-needle, I find that the cord can be lifted and moved laterally to such an extent as to enable us to inspect its anterior surface, and also the condition of the anterior wall of the canal in front of the cord. When such operative procedure as is necessary has been completed, the dura can be closed by a curved Hagedorn needle, or by the little suture-needle for the dura which I have devised (Fig. 4869, p. 210). The closure of the dura is very important in order to prevent the continuous loss of cerebro-spinal fluid. The wound, external to the cord, should be drained by a rubber tube and horse-hairs. The drainage-tube should be removed at the end of twenty-four hours, leaving only a few horse-hairs in place for capillary drainage for from three to five days. The wound should be closed in the usual way, and the ordinary antiseptic dressing applied. Possibly, two lateral binder's board, felt, or plaster-of-Paris splints may be of value to secure rest for the first few days.

Dr. S. Weir Mitchell (*Amer. Jour. of the Med. Sci.*, May, 1889) and Dr. H. C. Wood (*Medical News*, 1889, i., 76) have recently reported some remarkable results in Pott's disease from extension continued for a considerable time. Dr. Mitchell applies the traction to the chin and occiput, and Dr. Wood, by suspenders applied by a plaster-jacket. Even marked palsies have been benefited or cured. This mode of treatment deserves careful investigation, and seems to promise much. *W. W. Keen.*

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[1] British Medical Journal, 1888, i., 1273.
[2] Ibid., August 11, 1888. [3] Lancet, July 14, 1888.
[4] Brain, January, 1888, and British Medical Journal, 1888, ii., 881.
[5] British Medical Journal, September 22, 1888.
[6] Ibid., August 25, 1888. [7] Deutsch. Med. Woch., May 3, 1888.
[8] American Journal of the Medical Sciences, December, 1888.
[9] New York Medical Journal, November 24, 1888.

SPLEEN: HISTOLOGY AND PHYSIOLOGY OF.

HISTOLOGY.—The spleen may be divided conveniently, from a histological stand-point, into a supporting framework composed of connective tissue and unstriped muscle-fibres, and a parenchyma contained within the meshes of the framework. The framework or skeleton consists of a firm capsule enveloping the organ, and of a series of trabeculæ which, arising from the inner surface of the capsule, pass into the interior, divide, and subdivide, and anastomose with one another until, becoming finer and finer, they are lost in the parenchyma. At the hilus the trabeculæ which pass inward from the capsule carry within themselves the large arteries, veins, and lymphatics belonging to the spleen, and unite with the trabeculæ from other portions of the capsule to form the internal supporting framework. With this brief general sketch of the structure of the spleen, we can take up the different portions separately, and discuss their histology in more detail. Unfortunately, the minute anatomy of the spleen in some respects is still in doubt, so that it will be necessary to give conflicting views without being able to say to which side the balance of evidence tends. This is the more unfortunate as there seems to be no reason why careful investigation, with the present improved methods, should not settle definitely several of the points in dispute.

The capsule consists of a thin coat of peritoneum, provided with a layer of endothelial cells, and beneath this the much thicker tunica propria. This latter is composed of white connective-tissue fibres and cells, with a variable, though usually large, admixture of elastic tissue and unstriped muscle-fibres. In some animals, as the dog, the cat, and the pig, the muscle is present in large quantities, and is arranged, according to some histologists, in two layers, a longitudinal and a transverse; in man the quantity of muscle in the capsule and the spleen generally is relatively much smaller. The trabecular net-work continued into the interior of the spleen from the capsule is composed of the same histological elements as the capsule. In the dog and the cat, according to Kyber, the smaller trabeculæ are formed almost entirely of muscular tissue. We can easily recognize the muscle-cells, in stained sections of the spleen, by their characteristic elongated nuclei.

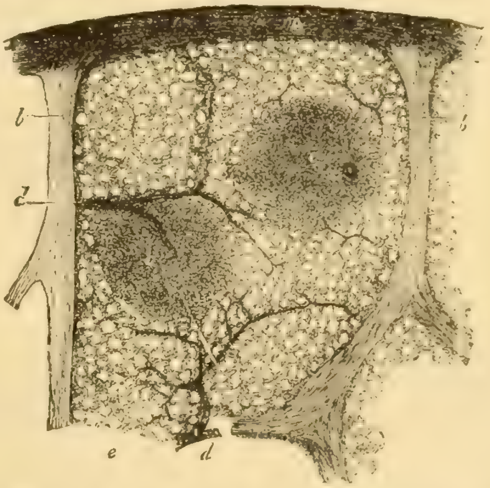

FIG. 5062.—Vertical Section of a Superficial Portion of the Spleen. A, peritoneal and fibrous covering; *b*, trabeculæ; *c c*, Malpighian corpuscles, in one of which an artery is seen cut transversely, in another longitudinally; *d*, injected arterial twigs; *e*, spleen-pulp. Magnified with a low power. (After Kolliker.)

The spleen parenchyma lying between the trabeculæ consists of the so-called spleen-pulp, the most characteristic portion of the spleen, of the Malpighian corpuscles and the lymphoid sheaths connected with them, and of the finer branches of the blood-vessels. The Malpighian corpuscles are easily seen, in most cases, upon a fresh-cut surface of the spleen, as white specks visible to the naked eye. Formerly they were described as distinct vesicular bodies, surrounded by a membranous sac and lying upon the smaller arterial branches, usually at their bifurcation. It is now known that this view is erroneous. The Malpighian corpuscles are simply collections of lymphoid tissue of exactly the same structure, as far as can be determined, as the lymphoid nodules found in various other parts of the body. In fact, the smaller arteries of the spleen, after reaching a certain size, are completely ensheathed by a thicker or thinner layer of lymphoid tissue, and what are usually described as Malpighian corpuscles are merely local enlargements of this sheath, the increase being sometimes only on one side of the vessel, sometimes on all sides, so that the corpuscle is pierced by the artery. The Malpighian corpuscles in man have an average diameter of 0.45 mm.; in the horse, 0.6 mm.; in the rabbit, cat, and dog, about 0.35 mm. (Kyber);

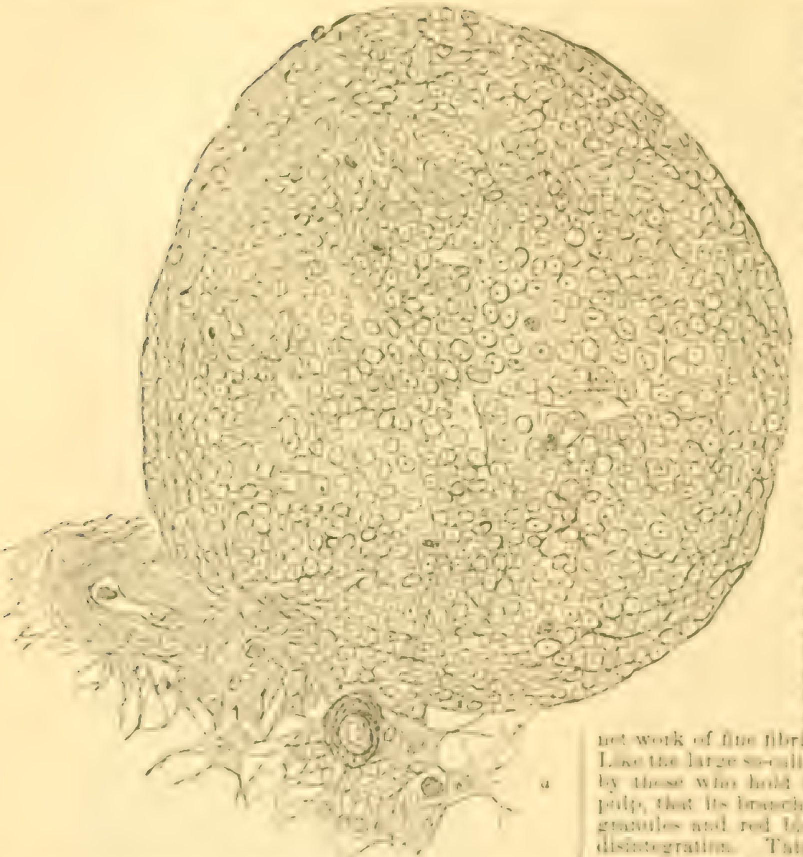

Fig. 5063.—A Malpighian Corpuscle from the Spleen of a Cat. The figure shows a small portion of the spleen pulp which surrounds the corpuscle. In the pulp is seen the cross-section of an artery to the right and of a vein to the left, both surrounded by lymphoid tissue. a, Wall of the corpuscle. (From a camera-lucida drawing of a spleen hardened in corrosive sublimate.)

they are always of a more or less spherical shape. It is said that the corpuscles are larger and more easily seen by the naked eye in an animal after a full meal than in one which has been starved. Microscopically, each corpuscle has the appearance represented in Fig. 5063. By far the most striking element in it is the ordinary lymph leucocyte; in fact, the Malpighian corpuscle seems to be a mass of these bodies, though usually only the clear vesicular nucleus with one or more conspicuous nucleoli is distinctly seen as represented in the drawing. The outlines of the cell-body are not shown in the sections, as a rule, though the granular protoplasm composing it is seen lying between the nuclei. As in other lymph nodules these leucocytes are embedded in an adenoid reticulum. On the periphery of the corpuscles the meshes of this reticulum are smaller and the fibrils are more distinct, while the leucocytes are closer and more tightly packed. Toward the middle, the reticulum becomes finer, with larger meshes, and the leucocytes are generally of a larger size and not so close together. The reticulum is said to show, in places, nuclei at the nodal points of the fibres as in other lymph tissues, indicating its derivation from metamorphosed cells. The Malpighian corpuscles are well supplied with blood; each receives a small artery from the main trunk to which it lies, as shown in Fig. 5064. This branch breaks up into an ordinary capillary net-work within the corpuscle. How the blood is collected from this capillary region is undetermined; at least two different views being held by the histologists who have made special investigations into the structure of the spleen. According to one view, the blood after leaving the capillaries passes into the venous radicles, and thence successively into larger and larger veins forming a connected vascular system, as in other organs. According to the other, the blood from the capillaries of the Malpighian bodies passes finally into the interstices between the pulp-cells, flowing there in irregular channels without definite walls and bathing the pulp-cells directly; from these channels it is gathered up by the small veins.

The pulp of the spleen is, perhaps, the most difficult part to understand; its structure is described differently by different authors. Most of the standard English histologies describe the pulp as consisting of large, flattened, branched connective-tissue or endothelial cells; during life these are probably soft and of a reddish-brown color, and form a honeycombed matrix by the union of their processes, through which the blood percolates. In addition, one finds in the meshes lymphoid cells of various sizes, the larger ones of which are called by Schäfer splenic cells, and are said to contain in many cases red blood-corpuscles. Schäfer states also that in some portions of the spleen the honeycomb of branched cells is replaced by a net-work of fine fibrils resembling an adenoid reticulum. Like the large so-called splenic cells, it is generally stated by those who hold to this view of the structure of the pulp, that its branched cells frequently contain pigment granules and red blood-corpuscles in various stages of disintegration. This appearance is considered as the strongest proof of the theory that the function of the pulp-cells is to destroy the red corpuscles. Figs. 5065,

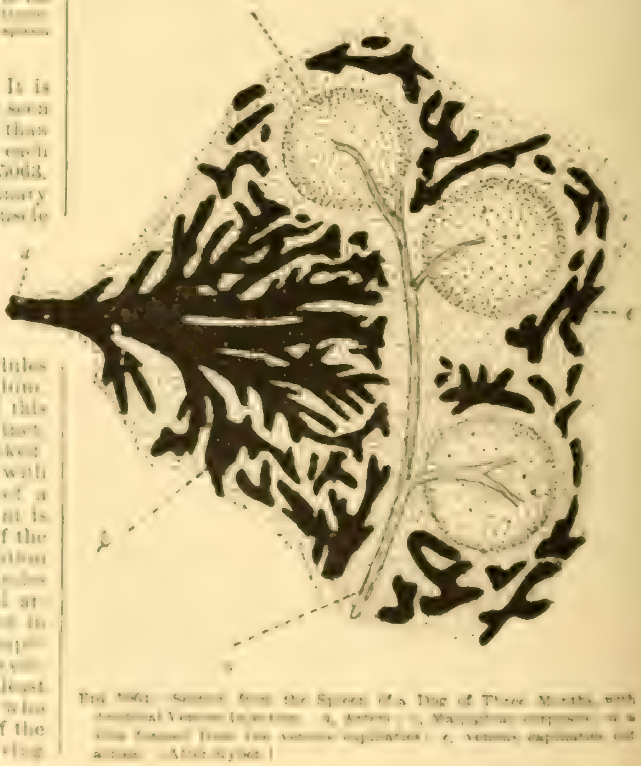

Fig. 5064.—Section from the Spleen of a Dog of Three Months, with [illegible] Venous Injection. a, Artery; b, Malpighian corpuscles; [illegible] formed from the venous capillaries; c, venous capillaries [illegible]. (After [illegible].)

and 5066, copied from Schäfer and Klein, respectively, give an idea of this view of the structure of the pulp. On the other hand, Kyber, Stöhr, and others, describe the pulp as consisting of a reticulum of fine fibres, in whose meshes are contained many leucocytes, as in the reticulum of the Malpighian corpuscles. Between these cells there exists what Kyber calls a granular intermediate substance, and the larger cells are described as containing, occasionally, red corpuscles. Kyber, Kölliker, and others affirm, moreover, as has been stated before, that the spaces in the pulp are not traversed by the blood stream; that, on the contrary, the blood-vessels here, as in other organs, form a closed system, the arteries passing into capillaries, and these again into the veins. Kyber believes that the pulp-tissue forms cords or tracts which lie in among the vascular tracts, and that the fine reticulum of the pulp connects directly with the reticulum of the lymphoid sheaths of the arteries and of the Malpighian corpuscles. In fact, the only distinction one can make between the two is that the reticulum of the pulp is finer and has smaller meshes. In this reticulum, in young animals, round or spherical nuclei can be found in great abundance, but in older animals they are met with only occasionally. Their occurrence indicates that the network was originally formed by the union of the processes of branched cells, the cellular character of the reticulum disappearing in the older animals. We must await further investigation before making a decision as to which of these views of the pulp structure is correct.

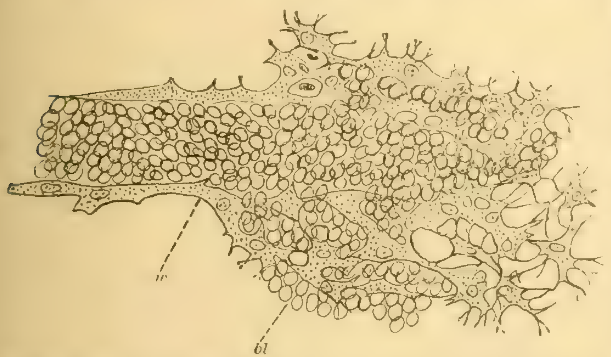

Fig. 5065.—Section of the Spleen-pulp, showing the Mode of Origin of a Small Vein in the Interstices of the Pulp. *v*, The vein filled with blood-corpuscles; *bl*, blood-corpuscles filling up the interstices of the retiform tissue of the pulp; *w*, wall of the vein. (Taken from Schäfer.)

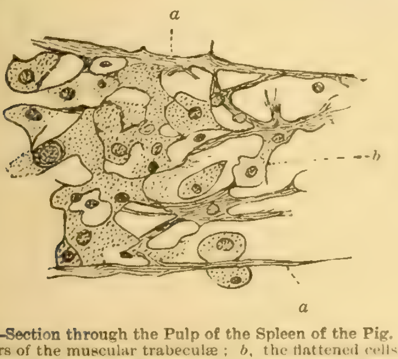

Fig. 5066.—Section through the Pulp of the Spleen of the Pig. *a*, Last outrunners of the muscular trabeculæ; *b*, the flattened cells, forming the honeycombed matrix of the pulp. In the meshes of this matrix are contained lymphoid cells of various sizes. (From Klein.)

With regard to the course of the arteries and veins in the spleen, something has been already said. One of the most careful accounts published is that by Kyber, founded upon a study of injected specimens. Most of the following description is taken from his paper. The splenic artery, before reaching the spleen, divides into a number of branches, from four to ten in the case of man, and thirty or more in dogs and cats. After entering the spleen the arteries run in the large trabeculæ along with the veins, and branch dendritically into smaller and smaller divisions. When the small arteries have reached a certain size, about 0.15 to 0.20 mm. in the human spleen, they part company with the veins, their connective-tissue sheaths become looser and infiltrated with lymph leucocytes, and finally the artery is surrounded by lymphoid tissue upon which, at intervals, the enlargements known as Malpighian corpuscles are developed. From time to time now the artery gives off smaller branches, each of which breaks up into a bundle of very fine arteries, and these end finally in the arterial capillaries. So far, it is important to notice, there are no anastomoses between the ultimate divisions of the main arterial stems which enter the spleen. The spleen, in fact, as far as the arteries are concerned, is a lobulated organ, the arterial supply of each lobule being independent of the others. The arterial capillaries are distributed in part to the Malpighian corpuscles, and in part, according to most authors, directly to the pulp. Those entering the Malpighian corpuscles form an ordinary capillary plexus, and some of the branches emerging from this plexus pass into the pulp to help make the capillary system there. The capillaries of the pulp do not form plexuses, but run isolated from one another, and on many of these fine vessels (called arteries by Klein) are found peculiar bodies to which the name of capillary sheaths has been given. They are more or less spherical structures, and each is pierced by one of the small vessels. The histology of these bodies is not yet satisfactorily known. They were described by the older histologists (Billroth, Schweiger-Seidel) as possessing a membrane, but Kyber believes that they are composed of a fine net-work with closer meshes than that of the surrounding tissue, and filled with lymph leucocytes; while Klein thinks that they consist of concentrically arranged endothelioid plates. With reference to the histology of the vascular system beyond the capillaries, there is a fundamental difference of opinion. The different views held have been mentioned already in speaking of the pulp-tissue. Many histologists believe that the capillaries open into the irregular spaces between the pulp-cells, whence the blood is collected first into incomplete tubes, the venous sinuses, which then pass into the veins proper, and finally entering the trabeculæ unite from different parts of the spleen to form the large efferent trunks. According to Kyber, whose view is in its general features that of many of the German histologists who have studied the subject specially, the capillaries have definite walls, and pass suddenly into vessels of larger size, the capillary veins, and these anastomose freely with one another, thus destroying the lobular character of the organ preserved in the distribution of the arteries. The capillary veins open into larger veins, which unite dendritically to form the chief trunks. Upon this view the splenic pulp-cells do not come into direct contact with the blood stream, and it is difficult to see how, under these conditions, they can function as destroyers of the red blood-corpuscles by directly ingesting them, as is usually described.

A possible compromise between the two views is found in a recent paper by Sokoloff. From investigations made upon the spleen of the rabbit, dog, and man, he concludes that the blood-stream under normal conditions moves in a system of closed vessels lined everywhere with endothelium. But in places the walls of the vessels are exceedingly delicate, and even a slight degree of hyperæmia will lead to a diapedesis of blood-corpuscles into the pulp-tissue, while in acute venous hyperæmia the interstices of the pulp become filled with red corpuscles.

The lymphatics of the spleen are very numerous, and their distribution has been carefully studied. The capsule contains a plexus of large vessels which are continuous with others found in the trabeculæ, and these in turn anastomose with a system of perivascular lymphatics accompanying the arteries. The connection of the lymphatic vessels with the lymphoid tissue, Malpighian corpuscles, etc., if any exists, has not yet been made out satisfactorily.

PHYSIOLOGY.—The function or functions of the spleen have always been a puzzle to the physiologist. Many curious theories have been proposed at different times to explain its use, founded in some cases upon careful experiments or observations, in some cases elaborated simply by processes of introspection, but in all cases unsatisfactory. The better methods, the more cautious deductions of modern physiology, have proved nearly as unsuccessful as the loose experiments and illogical conclusions of former days in arriving at anything positive and undisputed concerning the function of this organ, though modern investigations, it is true, have rendered valuable service in showing the absurdity or impossibility of many of the older theories, and in making us acquainted with a number of facts, with reference to the spleen, which may be looked upon as solid acquisitions, and which, when more carefully studied, will lead eventually to an understanding of its function. A brief mention of some of the hypotheses which were made by the older physiologists before passing on to an exposition of the present theories may not be without value, inasmuch as it will serve to show how completely the use of this organ has evaded the careful inquiries of the most able men, and how persistent the effort has been to invent some hypothesis which should give it a "raison d'être."

Hippocrates and Aristotle believed that the spleen in some way drew the watery parts of the food from the stomach, while Galen thought that it attracted certain juices from the liver which were further elaborated within its own substance, and partly retained as nutriment, partly transmitted to the stomach by the veins. After the discovery of the circulation, the favorite view seems to have been that the spleen purified the blood of its thick, melancholic portions. In the latter part of the seventeenth century Malpighi described for the first time the Malpighian bodies, though his idea of their structure was erroneous. He believed them to be small membranous sacs capable of forming a liquid secretion, and this conception prevailed among physiologists, with some modification, until well into the nineteenth century. Malpighi thought that these little sacs burst from time to time, and the liquid contents, passing into the veins, caused the formation of certain products in the blood, which, in turn, were carried to the liver, and were useful in the formation of the bile. During this period a number of very odd theories were proposed, some of them apparently without any sort of experimental proof, such as that of Havers, who taught that the spleen makes the synovial liquid. In 1722 Stukely suggested a theory which found many advocates, and in a somewhat modified form is often taught at the present day. He thought that the spleen acted as a diverticulum which was capable of receiving the surplus blood whenever this element, from any reason, was in excess; that it acted, in fact, as a safety-valve for the systemic circulation. The discovery, made shortly afterward, that the spleen shows considerable variations in size at different times, seemed to support this hypothesis and may account for its popularity. The great Haller, disregarding the important discoveries which had been made concerning the structure of the spleen, taught that it was composed entirely of arteries and veins. With regard to its use, he speaks in his "First Lines" of the blood becoming fermented in the spleen by the [illegible] of the adjacent colon, etc., the final product being something which, when taken to the liver by the blood, stimulates that organ to an increased secretion of bile. Hewson thought that the spleen had the power of changing the lymph particles formed in the lymphatic glands and thymus into red blood corpuscles; while Home, at the beginning of the present century, attempted to show that the spleen is the organ through which fluids are conveyed after absorption from the cardiac portion of the stomach. [illegible] supposed that the spleen belongs to the class of erectile tissues, and Tiedemann and Gmelin concluded from their experiments that the spleen is an organ closely connected with the lymphatic system, and that it "secretes a coagulating fluid from the arterial blood, which is taken up by the absorbents and conveyed to the thoracic duct." As late as 1827 Arthaud was guilty of believing that the spleen is simply a plexus of nerves, and functions as an electrical apparatus. Johannes Müller first formulated, perhaps, the general view of modern times, that the spleen has for its function the production of some change in the blood circulating through it; what that change is was of course unknown to him as it is to us. Gray, from whose book, "Upon the Structure and Use of the Spleen," the foregoing historical account has been chiefly taken, believed that the spleen regulates both the quantity and quality of the blood. It is interesting to notice that he asserted in many cases that the general nutritive condition of an animal was improved by extirpation of the spleen, and he explained this satisfactorily upon his theory, leaving us to infer that, perhaps, the regulating action of the spleen under normal conditions is of a disadvantageous character to the body as a whole.

Since the middle of the present century the conviction seems to have become established in the minds of physiologists that the spleen in some way is connected with the life-history of the red blood corpuscles. Either it takes part in the production of these bodies or else it is the organ in which they are destroyed, or possibly, in the opinion of some, it fulfils, curiously enough, both of these functions, serving as the grave as well as the birthplace of the blood corpuscles. Perhaps the balance of evidence, such as it is, inclines toward the hypothesis that the red corpuscles are destroyed in the spleen. Kölliker was the first seriously to advocate this view, and a clear account of his reasons for it may be found in his article on the spleen in Todd's "Cyclopædia of Anatomy and Physiology." The chief proof of his theory lies in the fact that one can find in the spleen, according to him, numbers of large white splenic corpuscles which contain within themselves one or many red corpuscles in various stages of disintegration. He traced the initial cause of this destruction of the corpuscles to the alterations in volume of the spleen. As the spleen expands and fills itself with blood, a stagnation, or possibly even an extravasation, occurs in the smaller vessels, and in this stagnant blood either the red corpuscles are dissolved, or, as stated, they are taken into the substance of the large splenic cells and there gradually disappear. This latter process he claims to have seen in all its stages. Ecker also described similar phenomena and gave them the same interpretation. Both he and Kölliker believed that the material of the disintegrated or dissolved red corpuscles was eventually taken to the liver through the portal vein, and there further decomposed to form the biliary pigments. An air of probability is given to this latter supposition by the fact that the splenic blood returns to the heart through the portal circulation; indeed, this connection between the two organs has always been looked upon, since the discovery of the circulation, as signifying some functional dependence of the one upon the other. Further evidence in favor of the theory that the red corpuscles are destroyed in the spleen has been found in the presence in the spleen of certain chemical products usually looked upon as indicative of active metabolic changes, substances such as uric acid, xanthin, leucin, tyrosin, several of the fatty acids, lactic acid, succinic acid, cholesterin, and, in addition, an albuminate containing iron. Properly considered, the occurrence of these products means only that active metabolisms of some kind are in progress, but that these metabolisms are connected with the death of the red corpuscles is at present a gratuitous assumption. This hypothesis, then, rests chiefly, if not entirely, upon a histological basis. That this alone is not satisfactory is felt by anyone who examines the spleen microscopically, for the existence of splenic cells containing red corpuscles has been doubted or denied by a number of observers; certainly they are not met with in every spleen, for the writer of this article has had occasion to examine many spleens in one animal, the cat, and has never yet seen splenic cells filled with red corpuscles as described by Kölliker. Occasionally, it is true, he has found such cells containing a single red corpuscle, but the ingestion of the corpuscle in these cases may easily have happened after death in consequence of the stagnation of the blood in the meshes of the spleen, as it is well known that the large splenic cells in question are actively amœboid. If the destruction of the red corpuscles by this method were the chief function of the spleen, one would expect to meet with such microscopic evidence of it more frequently and more constantly, considering the great number of red corpuscles which is supposed to be undergoing destruction at any one time. However, we find in most of the histologies the statement that such blood-corpuscle-containing cells occur in the spleen, the statement presumably resting on personal observations by the author; and the explanation usually adopted is the one of Kölliker, that it is a function of these cells to destroy the red corpuscles. So that it is fair to assert that this hypothesis is generally accepted at the present time. It is, perhaps, the only function of the spleen that is described with any show of certainty, though, as I have tried to indicate, the evidence for it is obviously unsatisfactory, and will scarcely stand a critical examination. If one chooses to believe that the red corpuscles are destroyed in the spleen, not by absorption into the substance of its amœboid cells, but by simple dissolution in the plasma while in that organ, there is nothing either to prove or disprove the belief, though a certain amount of possible evidence may be brought forward in favor of it, such as the large percentage of iron contained in the substance of the spleen, even when the blood is thoroughly washed out.

With regard to the theory that the spleen takes part in the formation of new red corpuscles, we are now in a position to discuss the question with some degree of certainty. The theory is always based at the present day, so far as the writer is aware, upon the assertion that developing nucleated red corpuscles can be found in the spleen. The recent investigations of Bizzozero, and Bizzozero and Torre, and others, have shown that this statement is probably erroneous; that among the higher mammalia, including man, one cannot find in the spleen of the healthy adult animal any evidence of this nature to show that it takes part in the production of red corpuscles. In fact the connection of the spleen with the formation of new red corpuscles, during fœtal and extra-uterine life, has been pretty clearly ascertained, thanks to the labors of Kölliker, Foa, Bizzozero, and others. The writer of this article, in experiments not yet published, made upon the regeneration of the blood-corpuscles in the cat, has been able to corroborate fully the general features of the connection of the spleen with this function, as stated by the authors just quoted; it is as follows: In the young fœtus, shortly after the spleen is formed, one can find in it numerous nucleated red corpuscles showing signs of an active multiplication by karyokinetic division, so that there can be no doubt that the spleen does possess this function during fœtal life. Before the appearance of the spleen the production of red corpuscles is confined to the liver, but toward the end of fœtal life, and for a variable period after birth, not only the spleen, but the marrow of the bones also, takes part with the liver in making new corpuscles. However, shortly after birth—in the cat by the third, or at the latest the fourth week—this function has disappeared entirely not only from the liver, but from the spleen also. Henceforward, throughout healthy adult life, the formation of red corpuscles is confined to the marrow of the bones, the spleen no longer takes part in the process.

Bizzozero and Torre have examined the spleens in a number of animals belonging to the different classes of vertebrates, and state that in none of them except the tailed amphibians does the adult spleen contain developing red corpuscles. But in the ordinary mammals, as the dog and the cat, and probably in man, the spleen of the adult under certain conditions can resume its fœtal function. Recently Bizzozero, and Bizzozero and Salvioli, have shown that in dogs and guinea-pigs, after the animal has been bled severely two or more times, the spleen upon examination is found to contain nucleated red corpuscles. The writer can confirm these observations from similar experiments made by him upon cats. In the normal healthy cat no nucleated red corpuscles can be found in the spleen; but if the animal is bled very strongly one or more times, and the spleen is examined twenty-four hours after the last bleeding, one finds in it a number of the nucleated corpuscles tinged with hæmoglobin, and frequently in different stages of division, showing, apparently, that the spleen has again taken on the function of making blood-corpuscles. Furthermore, Pellacani, and also Foa, state that in the spleens of human beings suffering from extreme anæmia before death, they have found nucleated red corpuscles, though in the spleen of man, normally, none are contained. These facts show quite conclusively that when the circulation is depleted of its red corpuscles by sudden and severe hæmorrhage, or in the human subject by the pathological conditions which bring on continued anæmia, the marrow of the bones is no longer able to supply the increased demand for new corpuscles, and the spleen takes part as an accessory organ in their production, as in fœtal life.

That the spleen is able to revert in this way to its embryonic function seems to depend upon the fact that, even in the healthy adult, one finds in it nucleated cells like nucleated red corpuscles, except that they contain no trace of hæmoglobin. Similar colorless cells are found in the marrow, and are regarded as the parent form of the nucleated red corpuscles. To these colorless predecessors of the red corpuscles Löwit has recently given the name erythroblasts, and states his belief that they are found not only in the marrow and spleen but also in the lymph glands. In the spleen these cells apparently do not, under normal conditions, develop into red corpuscles, at least not in the spleen itself; while under the stimulus of excessive anæmia they again begin this course of development. In this connection the recent investigations of Foa, Tizzoni, and Griffini and Tizzoni, are of peculiar interest. Foa states that if a portion of the spleen is excised by means of scissors or a cautery, the loss is replaced, after a certain time, by a new growth, and the portion of the spleen undergoing regeneration passes through the same stages as the developing spleen of the fœtus, that is, it contains a number of nucleated red corpuscles and giant cells. Tizzoni obtained the same result from partial excision of the spleen, and affirms, moreover, that when the organ is entirely removed new splenic nodules are formed in the great omentum, which show during their development the presence of nucleated red corpuscles. Foa, however, denies that under such conditions new splenic nodules are formed.

As far as the white corpuscles of the circulating blood are concerned, it is at present uncertain, or only an inference, whether or not the spleen takes part in their formation. The case may be fairly stated as follows: We know that the spleen contains a quantity of lymphoid tissue, both in the form of the Malpighian bodies and as the sheaths of diffuse lymphoid tissue surrounding the smaller arteries. It is at present the general belief that the white corpuscles of the blood are derived from the lymph leucocytes furnished by the lymphatic glands and other collections of lymphoid tissue scattered throughout the body. Accepting this theory, we must believe that the lymphoid tissue of the spleen also gives its quota of white corpuscles to the blood. The only weak point in the argument is the fundamental assumption that the white blood-corpuscles are simply modified lymph leucocytes; without doubt this is still open to question, though it is almost universally conceded to be true. In any case this spleen-tissue proper—the so-called pulp—cannot be considered as taking any part in the formation of white blood-corpuscles.

Efforts have been made to arrive at the function of the spleen by excising the organ entirely, and then determining the disturbances or changes in the animal produced by this operation; but the results have been entirely negative. The experiment has been performed frequently by physiologists on the lower animals, and a number of times by surgeons on the human subject, with the invariable result that even the entire removal of the spleen has no direct injurious result, so far as can be determined, upon a healthy animal. We are therefore justified in believing that the spleen is not absolutely necessary for the maintenance of the life of the animal. Whatever functions it may perform are of such a nature that they can be carried on by some other organ or organs after its removal. A number of physiologists have stated that in dogs, after excision of the spleen, the animal shows a ferocious disposition and an extraordinary appetite, but it is doubtful whether this result is peculiar to removal of the spleen. First records that he has noticed a similar change in animals from which one of the kidneys was taken. In any case, the change in the appetite and temper throws no light at all on the function of the spleen. Something more definite, as the result of excision of the spleen, is the effect on the lymphatic glands. Many observers state that in post-mortem examination of the animals operated on, these glands are usually found enlarged, indicating that the function previously performed by the spleen had fallen upon them. But this again is unsatisfactory, because, in the first place, the lymphatic glands have only one function that we are acquainted with, namely, that of making lymph leucocytes, and they can therefore only take the place of the lymphatic tissue contained in the spleen, and not of the spleen tissue; so that granting the observation to be correct, it throws no light on the peculiar function of the spleen. In the second place, other observers, equally as reliable, deny that any enlargement of the lymphatic glands occurs; while others, still, say that it happens in some cases but not in all. On the whole, then, we cannot place much weight upon this observation. Similar statements have been made concerning the effect of removal of the spleen upon the marrow of the bones. It is said that the marrow of the long bones becomes hyperæmic, and the yellow marrow is changed to red, capable of producing red corpuscles. If this is found to be true, as a permanent effect of excision of the spleen, it will be strong evidence, of course, in favor of the view that the spleen normally takes part in the manufacture of red corpuscles. But the observation rests upon insufficient experiments, is denied by some, and it is quite possible that when it occurs it is simply a temporary result of the loss of blood, as it is well known that in ordinary bleeding it is usual to get this effect on the marrow. Another result of total excision of the spleen, described by some authors, is the development of new spleens or splenic nodules. If this is so we can understand why so little apparent injury follows the operation. This statement has been warmly supported in the last few years by Griffini and Tizzoni. They assert, from numerous experiments, that after total excision a number of accessory splenic nodules are formed in the great omentum possessing the characteristic elements of the normal spleen. On the other hand, Foà contends that in every case where supernumerary splenic nodules are found after excision they were really present before the operation, as the omentum retains an embryonic tendency to produce these bodies, which may be aroused into action by a number of different causes. From this brief summary it is easy to see that the method of excision has not contributed much positive information to our knowledge of the spleen, though it has shown that this organ is not so essential as its large size would seem to indicate.

One of the most remarkable things about the spleen is that it undergoes frequent, and sometimes very great, changes in size, not only in malarial fever and other pathological conditions, but in the perfectly healthy person. This has long been known, and, in fact, the enlargement of the spleen has been shown to be connected with the periods of digestion of food. The spleen begins to increase in size after eating, and is said to reach a maximum about the fifth hour after a meal has been taken. This, together with the evidences in the spleen of the existence of active metabolic changes, and the fact that the splenic blood passes into the portal circulation, makes it possible that the spleen takes some part in the elaboration of the food during or after digestion, but anything more definite it is impossible to state. However, one physiologist, Schiff, has attempted to show a very definite connection between the spleen and the pancreas with reference to digestion in the small intestine, though the attempt has not met with any success in the minds of most physiologists. Schiff found that after excision of the spleen the pancreatic secretion could no longer digest proteids, that is, the pancreas was not able to make its proteolytic ferment trypsin. The explanation of this effect was that the pancreas by itself can only form a preliminary material—to use the term now introduced by Heidenhain, can only make a zymogen or trypsinogen, and to convert this zymogen into trypsin requires a ferment, which, under normal conditions, is formed in the spleen and carried to the pancreas by the blood stream. Schiff's fundamental experiment has been entirely unsuccessful in the hands of other physiologists. Ewald found that the pancreatic juice, after excision of the spleen, digested proteid without difficulty, and Heidenhain states, in the most positive terms, that in several dogs from which he had previously removed the spleen he was able to get a pancreatic juice, by means of a fistula, which digested fibrin in a perfectly normal manner. The only person who has been able to confirm Schiff's theory at all is Herzen. In one series of experiments, Herzen made a number of infusions of pancreas and of spleen, taken from dogs under different conditions, and determined their action when used singly or together upon fibrin. His results were as follows:

1. An infusion of the pancreas of a hungering dog was inactive.

2. The same infusion, when mixed with the spleen pulp from the same animal, was likewise inactive.

3. The same infusion of pancreas, mixed with the spleen pulp from a dog in full digestion, had a strong digestive action on the fibrin.

4. Infusion of pancreas, plus infusion of the spleen of a hungering dog, was inactive.

5. Infusion of pancreas, plus infusion of the spleen from a dog in digestion, had a digestive action.

In response to criticisms made by Heidenhain upon the methods used by him in these experiments, Herzen has recently completed a new series arranged in this way: He prepared, first, an infusion of the pancreas from five different dogs, and, next, an infusion of the spleen of two dogs in full digestion. With each of the five pancreatic infusions he made the following mixtures, and tested their digestive powers upon both fibrin and coagulated albumen.

1. One volume of pancreatic infusion, plus 2 volumes of water.

2. One volume of pancreatic infusion, plus 2 volumes of five per cent. boracic acid solution.

3. One volume of pancreatic infusion, plus 2 volumes of infusion of spleen in five per cent. boracic acid.

4. One volume of pancreatic infusion, plus 2 volumes of aqueous infusion of spleen.

He found that in all cases Nos. 3 and 4, the mixtures of pancreas infusion with spleen infusion, had a more powerful digestive action than the others. He concluded from this that the zymogen formed in the pancreas is changed to trypsin by a ferment formed in the spleen during its periodic dilatation. This conclusion is obviously illogical, and not warranted by the experiments. His infusions of pancreas without admixture of the spleen possessed digestive powers, and all that he is justified in concluding from his experiments, granting that they were perfectly accurate, is that an infusion of the spleen has the property of increasing the digestive action of extracts of pancreas, but that by no means proves that the spleen forms a special ferment capable of changing trypsinogen to trypsin. We can increase the digestive action of pancreas extracts by a number of reagents, all of which are supposed to act by changing the trypsinogen more completely into trypsin: to say that the infusion of spleen has the same effect, because of the presence in it of a special ferment which it is the function of the spleen to make, is not justified, unless purer preparations of such a ferment are obtained, and until it is shown that the favorable action of the spleen infusion was not owing to its alkaline reaction, to the presence of some of the extractives usually found in it, or to some similar cause. Besides, if Herzen's theory were correct, the excision of the spleen should at least weaken decidedly the digestive power of the pancreatic secretion, but the experiments of Ewald and Heidenhain prove that this is not the case.

The most hopeful experiments that have been made upon the spleen, in the past few years, are those of Roy. He placed the spleens of living animals in a metal box filled with oil, and made tight by a flexible membrane lining it, and adhering to the contained organs. The instrument is known as the oncometer, and when in use its cavity, filled with oil, is connected by tubing with a recording apparatus, the oncograph. This latter gives a tracing showing the variations in volume of the oil in the oncometer, or, in other words, the variations in the size of the spleen. The whole apparatus can be so arranged that the spleen is kept at its normal temperature during an experiment, and its blood-vessels, nerves, and lymphatics are not interfered with. The most remarkable result that came out of Roy's experiments was the discovery of the fact that the spleen is never entirely at rest, but is continually expanding and contracting with a rhythm which is fairly regular. The expansions and contractions, or systoles and diastoles, as Roy terms them, number on an average about 62 to 63 in a minute for the dog and cat. The extremes of rapidity of rhythm were from 46 seconds to 2 minutes 3 seconds for each contraction. As a reason for these splenic beats, Roy asserts that the force which impels the blood through the substance of the spleen is not, as in other organs, the pressure in the arteries, but the contractions of the spleen itself. The machinery for these spleen contractions is found, of course, in the muscle-fibres scattered throughout the capsule and trabecular framework. In addition to these quick and rhythmic contractions, the spleen undergoes remarkable variations in size, slow expansions and contractions, lasting perhaps through hours. A number of different conditions may bring about these slow changes of bulk—for instance, the injection of various substances into the blood—and Roy believes, from his observations upon the spleen while in the oncometer, that under normal healthy conditions it is continually undergoing, from one reason or another, gradual variations in volume like those usually described as occurring during the digestion of a meal. As stated above, the object of the quick rhythmic contractions seems to be the driving of the blood through the spleen substance itself. The mass of blood in the spleen, Roy says, seems to be cut off to a great extent from the arterial system. Although this fact has been surmised by most physiologists, from the great capacity of the vein capillaries of the spongy spleen compared with that of the arteries, Roy now gives a definite proof for it. He finds that if the aorta of an animal with its spleen in the oncometer is clamped below the diaphragm, the blood-pressure in the spleen does not drop quickly as it does in other organs, the kidney for example, but, on the contrary, falls very slowly, indicating, as Roy expresses it, that the passages by which the blood enters the substance of the spleen must be very narrow. By means of his oncometer Roy was able to study more accurately than had before been possible the effect of stimulation of the nerves of the spleen. His experiments upon this point confirm and extend the older observations of Tarchanoff and others. He finds that direct stimulation of the vaso-motor centre in the medulla by electricity, or indirect stimulation of the same centre by making the animal dyspnœic, brings on a rapid and strong contraction of the spleen, a vaso-constrictor effect caused by a narrowing of the arteries in the spleen, and possibly also by a contraction of the spleen-muscle itself. In like manner, stimulation of the central end of a sensory nerve causes a contraction of the spleen, and finally, direct electrical stimulation of the divided splanchnic or vagus produces the same result. The last experiment shows that the vaso-constrictor nerves pass in part to the spleen through the vagus and splanchnic nerves, by way of the solar plexus. But the spleen evidently receives nerve-filaments from some other source, inasmuch as after section of the two splanchnics and the two vagi, stimulation of a sensory nerve will still cause a reflex contraction of the organ. Moreover, it was found that section of all the principal nerves going to the spleen had so little effect on its rhythmic contractions that Roy thinks it probable that these movements are regulated by some mechanism in the spleen itself, that is, by an intrinsic nervous apparatus, or by the automatic contractility of the muscle-fibres. These observations are a very welcome addition to our knowledge of the physiological properties of the spleen. Though they seem to give no direct information as to the functional value of the spleen to the body, there is no doubt that when followed out more thoroughly they will furnish material aid in the discovery of the long looked-for function of this organ.

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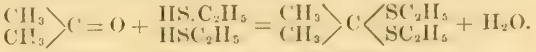
W. H. Howell.

SULPHONAL. (Spelled also Sulfonal.) Under this name Professor A. Kast recently (April, 1888) called attention[1] to the action of a new chemical compound which, in physiological and clinical experiments, he had found to be an efficient and harmless hypnotic. It was discovered by E. Baumann in 1885, and by him named diethyl-sulphon-dimethyl-methane. Its formula is $(CH_3)_2 = C = (SO_2C_2H_5)_2$.

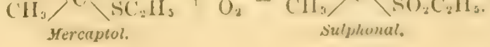
Preparation.[2]—Dry hydrochloric acid gas is passed into a mixture of two parts of ethyl-mercaptan and one part of acetone. The liquid gradually becomes warm and turbid, and separates into two layers, of which the upper is mercaptol, and the lower dilute hydrochloric acid:



$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>C=O+\begin{matrix}HS.C_2H_5\\HSC_2H_5\end{matrix}=\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>C\left<\begin{matrix}SC_2H_5\\SC_2H_5\end{matrix}\right.+H_2O.$$

Acetone. *Mercaptan.* *Mercaptol.*

The mercaptol is removed from the watery layer, washed first with water, and then with a dilute solution of hydrate of sodium, dried by means of chloride of calcium, and finally distilled. To oxidize the mercaptol and thus convert it into sulphonal, it is agitated with a five per cent. solution of permanganate of potassium, which is added as long as it becomes decolorized, or until the mixture becomes permanently red, showing that oxidation is complete. Occasionally, a few drops of acetic acid or dilute sulphuric acid are added, to combine with the liberated alkali. Finally, the liquid is heated in a water-bath and filtered hot. As it cools, the sulphonal crystallizes out. The crystals are obtained perfectly pure by recrystallizing several times from boiling water or alcohol:



$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>C\left<\begin{matrix}SC_2H_5\\SC_2H_5\end{matrix}\right.+\begin{matrix}O_2\\O_2\end{matrix}=\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>C\left<\begin{matrix}SO_2C_2H_5.\\SO_2C_2H_5.\end{matrix}\right.$$

Mercaptol. *Sulphonal.*

Properties.—Sulphonal crystallizes in colorless prisms which are inodorous and nearly tasteless. Most writers describe pure sulphonal as destitute of any perceptible taste, while others found it, when mixed with various liquids, slightly bitter. It is soluble in about 15 parts of boiling water, in about 100 parts of water at 37° to 38° C., and in about 500 parts at 15° C.; in 2 parts of boiling alcohol, in 65 parts of alcohol at 15° C., and in 110 parts of fifty per cent. alcohol.

Its solubility[2] in water is somewhat increased by the presence of small quantities of chloride of sodium, hydrochloric acid, and peptones. Thus it dissolves in 290 parts of a two per cent. solution of chloride of sodium at 40° C., and in 290 parts of a two per mille solution of hydrochloric acid at blood heat (38° to 40° C.). A hot solution of sulphonal, added to artificial gastric juice containing an abundance of peptones in solution, will not crystallize out in one hour when the liquid is cooled to blood-heat, even when the sulphonal constitutes one per cent. of the liquid.

Sulphonal is a remarkably stable compound.[3] At ordinary temperatures concentrated sulphuric acid, fuming nitric acid, nitro-hydrochloric acid, caustic potassa and soda, chlorine and bromine, do not affect it.

Tests.—Sulphonal should be colorless, odorless, and tasteless, or only very slightly bitter. Applied in substance to moistened red or blue litmus-paper, it should be perfectly neutral. It should melt at 125° to 126° C., and when incinerated should leave no incombustible residue. A hot watery two per cent. solution should not be altered by the addition of chloride of barium or nitrate of silver; and ten c.c. of the solution, on the addition of one drop of volumetric solution of permanganate of potassium, should become permanently red.[4]

Physiological Action.—According to Professor Kast, moderate doses of sulphonal, two grammes (30 grains), given to dogs, in about half an hour produce inco-ordinate movements, beginning in the legs, and soon extending to the trunk. The animals quickly become very helpless, and stagger about as if intoxicated with alcohol. In a short time they are unable to stand, lie down, and fall into a profound sleep. After awakening they are still somewhat uncertain in their movements, but speedily regain their normal condition, and then exhibit no trace of disagreeable effects. Very powerful dogs often present only the ataxic movements, but no hypnotic condition. Toxic doses cause severe convulsions, soon followed by deep stupor, and in about ten hours by death. The blood-pressure was carefully examined, and found normal during and after doses which caused prolonged sleep.

From the phenomena observed in animals after moderate doses of sulphonal, Kast concluded that this substance has a very decided physiological action, and probably first acts upon the gray cortex of the cerebrum.

In healthy middle-aged men, sulphonal, in doses of two to three grammes given early in the afternoon, several hours after dinner, soon causes sleepiness and dulness, which continue for some hours. Even these slight effects may not take place in very strong men, especially if they walk about in the open air. But they become more marked, and are soon followed by sleep lasting four or five hours, if the person lie down in a noiseless apartment. Thus, given to healthy men, in doses of two to three grammes, at a time when sleep is not required, sulphonal does not act like the narcotics and hypnotics which force sleep, but only produces a certain degree of dulness and languor, which is apt to increase and produce a spontaneous need of sleep. Ataxic movements, such as almost constantly occur in dogs, were never observed in men.

According to the investigations of Wm. J. Smith,[5] sulphonal, given in moderate doses, is completely changed in the organism into readily soluble organic compounds of sulphur. The quantity of sulphuric acid excreted is not altered, which shows that the organic compounds have great stability. Sulphonal exerts no influence on tissue-change, and does not increase or diminish the quantity of nitrogen eliminated. Large doses given to a dog for five weeks caused no disturbance of the animal's health, but minute quantities of unchanged sulphonal could be detected in his urine.

Therapeutical Uses.—The hypnotic action of sulphonal was tested by Kast about one hundred and twenty times on thirty patients. In most cases the sleeplessness was due to over-excitation of the brain, and occurred in neurotic patients; in some the insomnia was caused by organic cerebral disease, or was due to senility, or fever, or to disordered circulation from heart disease. Nearly invariably, in from one-half to two hours, quiet and dreamless sleep ensued, and lasted from five to eight hours. During the sleep the functions of circulation and respiration were somewhat slowed, as in natural sleep, but no deviation of the blood-pressure from the normal state could be observed. After awakening, the patients felt refreshed and presented no after-effects, except that in a few instances a feeling of fatigue and languor existed during the following morning or day.

Since the publication of Kast's observations sulphonal has been extensively used as a hypnotic in cases of insomnia. It was found to be most effective in nervous sleeplessness, and generally also when insomnia was caused by disease of the brain, disordered circulation, and neuralgia. It failed in some cases of delirium tremens, and had little effect in some hysterical, maniacal, and delirious patients. It also failed when insomnia was caused by severe cough, or intense pain other than neuralgia. Usually no disagreeable effects followed its action, or at most some dulness, languor, and sleepiness on the following day. In a few instances after repeated administration, there followed headache, vertigo, and tinnitus aurium, and in others eruptions resembling measles or scarlatina, attended with itching, and lasting several days.

Dose and Administration.—The average dose for patients of medium weight is two grammes (30 grains). Females rarely require more than from one to two grammes, while strong, heavy men often need from two to four grammes. The dose deemed appropriate should be given about two hours before bedtime, and one or two hours after the last meal, as then all the conditions are present which favor speedy solution and absorption: an abundance of liquid, chloride of sodium, hydrochloric acid, and peptones. The patient should be directed to take the dose in about half a pint of warm liquid—tea, bouillon, soup, etc.

℞ Sulphonal .... ʒ j.-ij.
Pulve bene. Div. in p. aeq. iv. S.: One powder in the evening.

Samuel Nickles.

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[1] Berliner klinische Wochenschrift, No. 16, April, 1888.
[2] Bernhard Fischer: Die Neuern Arzneimittel, p. 64. Berlin, 1889.
[3] A. Kast: Therap. Monatshefte, 1888, p. 316.
[4] B. Fischer: Die Neuern Arzneimittel, p. 67.
[5] Therap. Monatshefte, 1888, p. 567, November.

SUPRA-PUBIC CYSTOTOMY. The early history of this operation is so well known that but a brief sketch will be necessary.

In the year 1561, Pierre Franco, cutting a boy about two years of age by the perineal incision, found a stone too large to be drawn out through the pelvis; and driven by the importunities of the parents and the necessities of the case, he pressed the stone up from below with the fingers in the rectum, and cut down upon it over the pubes by an incision a little to one side of the median line.

Through this opening he succeeded in removing the stone, and although the child was very sick after the operation he finally recovered.

So impressed was Franco with the difficulties and dangers of this operation, and with the belief that wounds of the body of the bladder were almost necessarily fatal, that he advised strongly against a repetition of the procedure which had proved so successful in his hands.

In the year 1580, François Rousset, who had become interested in the subject, perceiving the importance of distention of the bladder to increase the space between the peritoneal fold and the pubic bone through which the operation could be made, advised that the bladder be filled with barley-water, milk, or some mucilaginous fluid, and that the penis be afterward compressed to prevent the escape of the distending fluid. For cases of small and contracted bladder he advised efforts at gradual distention by diuretic drinks, with forced retention of urine as preliminary treatment.

The operation, he thought, should be done on the patient in a horizontal position, with the pelvis raised, so that the force of gravity should tend to draw away the intestines, and that the liquid in the bladder might tend to gravitate toward the fundus and press it upward.

He advised that the incision should be made in the median line between the recti and pyramidales muscles, down to the bladder wall, which should then be entered by a small opening, to be afterward enlarged according to need with a probe-pointed bistoury. The peritoneum is to be retracted and protected by the forefinger during the incision of the bladder-wall.

These recommendations of Rousset are given at some length to show that, thus early, a plan was proposed which differed but little from that carried out in the modern operation. This is the more interesting when it is known that Rousset was not a surgeon, and therefore never performed the operation he so ably planned.

The operation did not obtain a firm foothold in the surgical world until the eighteenth century, when it was revived by Douglas (1719), Cheselden (1723), and Morand; but then only as an exceptional method.

Toward the end of that century (1779), Fr. Côme (Baseilhac) introduced the sonde-à-dard, with the aid of which he did many successful operations. His method of using this instrument was as follows:

When the median incision, close above the pubes, had been carried down to the bladder-wall, the sound, with its concealed dart, was introduced into the bladder. The operator then put the forefinger and thumb of his left hand to the bottom of the wound, and with his right hand carried the beak of the sound, with a see-saw movement, along the anterior bladder-wall until its point came under the middle of the wound. The handle of the sound was now depressed, and the point raised a nipple-like projection of the bladder-wall, which was seized with the left finger and thumb. During this part of the operation the peritoneum was carefully pushed toward the umbilicus.

The sharp-pointed director was now pushed out of the sound, appeared through the bladder-wall, and served as a guide to a bistoury which made a small opening through which the index-finger was at once slipped to hook up and hold the bladder, and to serve as a guide for further incisions, and for the manipulations of removing the stone.

Fr. Côme also practised and recommended a perineal incision for the purposes of drainage in patients cut over the pubes.

For more than a century after this the operation remained practically at a standstill in the matter of technique; and in the estimation of surgeons it steadily declined in importance, on account of its high mortality and of the improved methods of treating large stones through the perineal incision with powerful crushing instruments.

In the "Dictionnaire de Médecine," published in Paris in 1844, is a fair summary of the feeling of that time. The advantages of the operation, in the avoidance of hæmorrhage and of interference with the urethra and prostate, are dwelt upon, as well as the fact that it is the only possible operation in cases of very large stones.

On the other hand, the author draws a gloomy picture of the course and fatal effects of urinary infiltration, and closes by saying: "It is, then, owing to the danger of urinary infiltration after this operation that the great majority of surgeons have preferred, and still prefer, the narrow and embarrassed route that the perineum presents to urinary calculi."

This opinion of the operation, expressed in 1844, was not materially altered during the subsequent thirty years, and it was reserved for the removal of very large stones which could not be got out through the pelvis.

The technique usually followed during this period was essentially that of Fr. Côme, with the sonde à-dard, although occasionally the operation was done after the manner recommended by Rousset, over a full bladder.

In October, 1878, Dr. Garson, of Edinburgh, published some investigations, made in the laboratory of Professor Braune, of Leipzig, upon the changes of position of the pelvic organs, when the rectum was distended by an inflated rubber bag.

The surgical importance of his observations was at once manifest, for he found that the bladder was lifted out of the pelvis to a very considerable degree, and that thus the prevesical peritoneal fold was widely separated from the symphysis pubis, giving ample room for the performance of the supra-pubic incision without fear of injury to the peritoneum. At about the same time Professor Braune brought this matter to the attention of German surgeons, and in 1880 Professor Petersen appeared with an article, in Langenbeck's *Archiv für Klinische Chirurgie*, recommending the procedure as a good one surgically, reporting two cases operated on in this way, and recounting a number of additional observations on the cadaver.

From that time but little has been added to the technique of the operation, and the following description of procedure conforms pretty closely to that given by Petersen:

Preparatory Treatment.—If the bladder is much contracted, efforts may be made with warm injections to gradually stretch it to a reasonable capacity, and if there is cystitis present, with fermenting urine and mucus, an emollient and mildly antiseptic solution of borax or boracic acid may be used for this irrigation. On the day of the operation the bowels are to be thoroughly emptied by laxatives and enemata.

Operation. — The patient being fully etherized, an oval or pear-shaped rubber bag with a pipe attached is introduced into the rectum. This is more easily done before the bladder is filled. Before distending the rectal bag the bladder should be thoroughly irrigated and then filled with a boracic-acid solution.

The distention of the bladder should be done with extreme care, as rupture of the viscus has occurred in several instances during this procedure. If a bulb syringe is used, the hand recognizes the amount of resistance and can judge with considerable accuracy of the tension in the bladder. It is to be borne in mind that these bladders have usually been long diseased, and are not infrequently weakened by ulceration or sacculation. In most cases from six to ten ounces may safely be thrown in.

To prevent subsequent leakage of the water from the bladder, an elastic band should be tied around the penis. The catheter through which the injection has been made may either be withdrawn or closed with a clamp. The rectal bag is now to be slowly filled with water, and here, too, great care should be taken against over-distention, for there is danger not only of rupture of the rectum, but also of so increasing the tension in the bladder by pressure as to cause a rupture there. During the filling of the rectal balloon the rise of the bladder into the abdomen can be watched by palpation and percussion.

The accompanying figures show very well the effect of this rectal distention on the position of the bladder and of the prevesical fold of the peritoneum. They are reduced from full-sized illustrations of an article by Fehleisen, in Langenbeck's *Archiv für Klinische Chirurgie*, which were made for him from frozen sections of the cadaver.

In Fig. 5067, when the bladder is moderately distended, while the rectum is empty, the peritoneum reaches almost down to the upper edge of the pubes; while in Fig. 5068, although the bladder contains less water than that in Fig. 5067, yet the filling of the rectum so forces it up out of the pelvis as to lift the peritoneal fold to a good distance from the symphysis pubis. In Figs. 5069 and 5070 we see the same point still more strikingly illustrated.

Bouley has made investigations on this subject, and has deduced the following rule for determining the position of the peritoneal fold by percussion and palpation of the bladder: "When the apex of the bladder stands more than five and less than nine centimetres above the pubes the peritoneal reflection will be found three centimetres below this point. If the bladder reaches more than nine and less than sixteen centimetres above the symphysis the peritoneum will extend four centimetres below its apex.

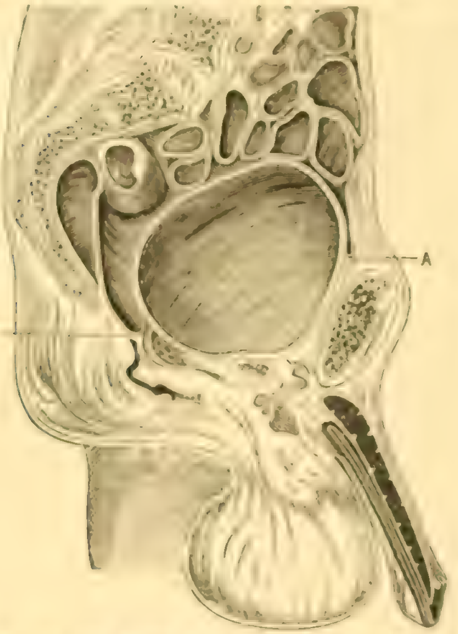

FIG. 5067.—Cut from Frozen Section. Bladder contains ten fluidounces. A, prevesical fold of peritoneum; B, retrovesical peritoneum. [illegible]

Besides the lifting of the peritoneum and consequent enlarging of the space through which the operation can be done, the rectal distention has a second good effect in pressing the bladder close up against the abdominal wall and fixing it there, so that it can be readily opened without obliging the operator to grope behind the pubes for it. It is this effect of the rectal ballonnement which has done the most to reduce the mortality of the modern operation.

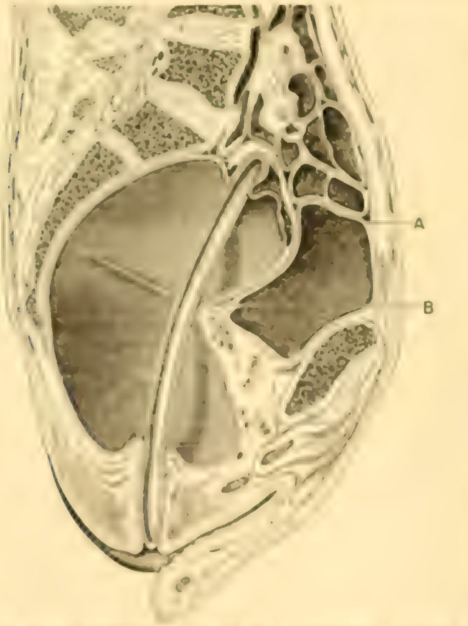

FIG. 5069.—Bladder contains six and a half fluidounces. [illegible] A and B mark the peritoneal folds.

Formerly, a good operator could with care avoid injury of the peritoneum, but in the exercise of the traction requisite, the loose attachments about the neck of the bladder were often considerably separated, thus opening the way for infiltration of urine and septic absorption, which were the usual causes of death in these cases. As most of this handling is now avoided, infiltration of urine and phlegmonous processes have become more rare.

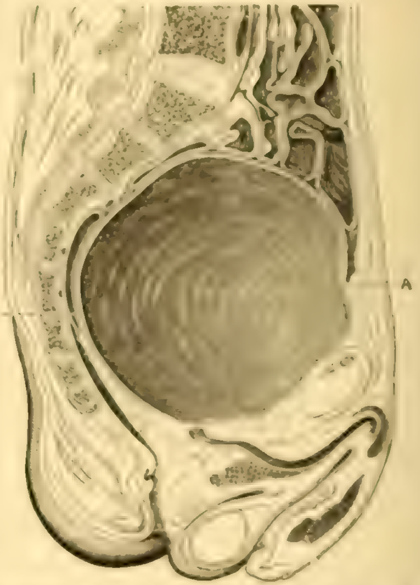

FIG. 5068.—Bladder distended with twenty fluidounces. A and B, folds of peritoneum.

To return now to the steps of the operation. When the bladder and rectum have been filled, or so far distended as seems safe, and the field of operation has been thoroughly scrubbed and shaved, an incision is made in

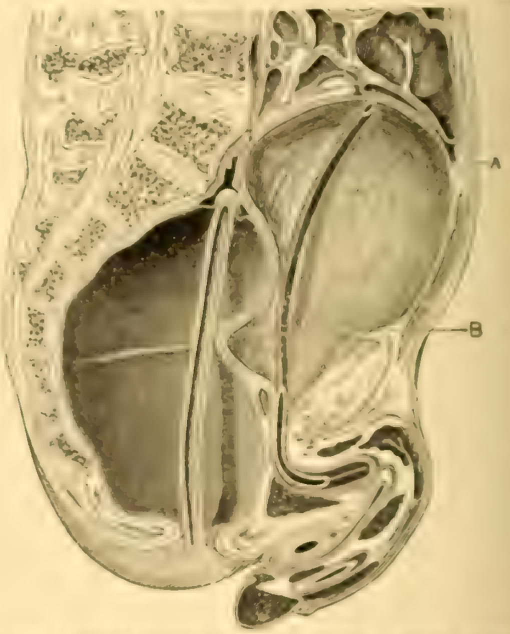

FIG. 5070.—Bladder contains fourteen fluidounces. Rectum distended with sixteen fluidounces. A and B, folds of peritoneum.

the median line, extending two and a half to four inches upward from over the symphysis pubis. The length of this opening will be varied according to the thickness of the abdominal wall.

The incision is carried down between the recti and pyramidales muscles into the prevesical space (cavum Retzii).

In many cases the bladder-wall is now at once in plain view, but in others a layer of cellular tissue, containing more or less fat, has to be separated. This should be done by dividing it directly down toward the bladder, and any dissection or separation of these loose tissues laterally should be carefully avoided.

Sometimes veins of considerable size lie at the bottom of the prevesical space, and these, when seen, may be clamped and cut, or, if possible, pushed to one side. If they are injured and give rise to troublesome hæmorrhage, it should be borne in mind that this bleeding usually stops when the bladder-wall is incised, much as the venous hæmorrhage in the neck, in the operation of tracheotomy, ceases when the trachea is opened. So that, if the bleeding points are not easily seen and caught up, the search should not be prolonged, but the bladder should be at once opened.

It will occasionally be found that the peritoneal fold is held down in close proximity to the pubes by a prolongation of delicate fascia (transversalis fascia, fascia propria of Velpeau) which attaches it to that bone. When this is the case it can be easily separated with the scalpel and drawn upward.

The bladder, when uncovered, should be opened by a clean thrust of the knife. The left forefinger, which is, during this part of the operation, protecting, and when necessary, holding up the prevesical fold of the peritoneum, should be at once slipped into the opening while it is distended by the escaping urine. The incision can then be enlarged according to need, either by stretching or with a probe-pointed bistoury. If the cystotomy has been done for the removal of a stone, the opening should be sufficiently large to allow the passage of the calculus without undue bruising of the edges of the incision.

The After-treatment of the Supra-pubic Wound.—The first important question we have to decide, in the matter of the after-treatment, is whether to apply sutures to the bladder wound or not. There is considerable difference of feeling among operators as to the wisdom of doing so. Statistics are too meagre to prove either plan decidedly superior, but as far as they go they show that patients have done better when the bladder wound was not closed, but was used for drainage. The added danger in the cases where the wound was closed seems to come from the increased chance of infiltration of urine and septic infection when the bladder leaks after the outer part of the wound has partly united.

The failure to unite has, no doubt, been due in many instances to the fact that improper cases were chosen for closure. It is evident that when the bladder-wall is much inflamed, especially in old and broken-down subjects, the chances of healing by first intention are very small, and the dangers of urinary infiltration are proportionately large. Only those cases, then, should be selected for suture in which the bladder is tolerably free from inflammation.

Further, if there is much hæmorrhage into the bladder, which cannot be checked at the end of the operation, this is to be looked on as a contraindication to the closure of the bladder-wound by sutures. For it is difficult in such cases, by perineal tube or catheter, to conduct off the urine, owing to the stoppage of the tubes by clots; and when these are clogged the efforts of the bladder to free itself soon reopen the wound.

In spite of these drawbacks in the use of the sutures of the bladder, the quick recoveries which are obtained in those cases in which the suture does hold are so striking that operators are constantly endeavoring, by improvement in technique, to make first intention of the supra-pubic wound a comparatively sure thing, and many are so sanguine as to believe that this effort will finally be successful, and will place the supra-pubic incision easily at the head of the procedures for treating the interior of the bladder.

Many forms of continued and interrupted sutures have been used in these wounds, but perhaps the most useful one has been the interrupted Lembert suture, which is easily applied and has the advantage of bringing broad surfaces together.

In applying any suture it is a good plan first to fix a thread at each end of the incision, by which the wound may be steadily held in view during the application of the intermediate stitches.

Some operators have advised that the outer surface of the bladder-wall be dissected off for a short distance around the incision, in order to prepare a fresh, raw surface which shall readily unite when drawn together by sutures. Antal suggests that an oval surface be thus denuded before the cavity of the bladder is opened, and that the incision be then made in the middle of this refreshed area. Whatever plan is used, care should be taken that none of the stitches penetrate the cavity of the organ, for not only would they favor the escape of the urine and thus make first intention almost impossible, but they would also be likely to serve as a nucleus around which calcareous deposits would form.

When the bladder wound is sutured, provision has to be made for the escape of urine, either by passing a catheter through the urethra and securing it there, or by putting a tube out through the perineum. The latter plan affords the best drainage, but involves an additional operation. Dr. Keyes has sought to reduce this operation to a minimum by the following procedure: He passes a sound from the bladder into the membranous urethra, and making its point prominent in the perineum, cuts down upon it by a very small incision. Through the opening thus made, a probe is passed up into the bladder, which draws after itself a thread, which in turn pulls in a catheter.

The other plan for the treatment of these wounds, and the one which thus far has had the most success, is by keeping the wound open and draining the bladder through it.

It is well to use two tubes for this, and their ends should be carried down to the bottom of the bladder when it is collapsed in the pelvis after the rectal bag is removed. The use of two tubes is a safeguard against the escape of urine being stopped by clots, and they are useful for irrigation. They should be secured to the skin, and their ends should be left long enough to dip down into a bottle between the thighs, or, if preferred, they may have attached to them a longer piece of tubing which hangs down over the side of the bed, and acts as a siphon to draw the urine out of the bladder. Some operators prefer to keep their patients on the side or belly, to favor drainage, but this is usually not necessary.

After thorough irrigation the wound should be dressed antiseptically, with iodoform gauze covering it closely around the tubes, and an absorbent dressing outside of this.

For the first few days the bladder may be irrigated with a solution of boracic acid several times in the twenty-four hours. After a few days one tube may be left out, and a catheter may be passed through the urethra and tied in. When this is working satisfactorily, and after the wound has contracted pretty well, the remaining tube may be removed, and the supra-pubic wound soon closes.

Indications for the Choice of the Supra-pubic Operation.—It is difficult at this time to lay down any exact rules for guidance in the selection of this operation. The modern operation of epicystotomy is so new as to be still on trial, and the statistics of mortality after it are not yet sufficiently determined to allow a fair comparison with the older rival methods. Furthermore, among these rival operations we have one (litholapaxy) which is almost equally young, and since the adoption of antiseptic precautions in surgery the results of the other cutting operations have been so vastly improved that, for purposes of comparison, only statistics of operations done since the general adoption of aseptic methods can be allowed. The operators of the present day are making the statistics by which this question will finally be judged.

Certain things are, however, plain. We have several operations, among which a selection may properly be made, which are wholly dissimilar in their methods and which have each their own difficulties and advantages. The cases to which these operations are to be applied are often complicated by a variety of conditions which may make now one, now another, procedure preferable. That surgeon will, therefore, be the most successful who, being an advocate of no system, studies each case with the purpose of applying to it that method of operation which best meets its needs, and avoids the dangers that surround it.

In considering the operation before us it will perhaps be easiest to discuss in turn the various conditions to which it may or has been applied.

First in importance we have *the removal of stone*. Until very recently this was the only application which the high operation found; and as the perineal operations had a smaller mortality the supra-pubic incision was reserved only for those cases in which the stone was too large for safe removal through the pelvis.

Since the revival of epicystotomy, with the improved modern technique and under the protection of antiseptic precautions, there have been a certain number of surgeons, mostly in Germany, or in those countries that get their medical instruction largely from German sources, who have gone so far as to claim that this is the proper operation for all cases of stone. These advocates of supra-pubic lithotomy claim that it is superior to the perineal operations because it avoids injury of important structures, such as the urethra, the prostate, and seminal ducts; because the hæmorrhage in it is less and is more under control; and because in case of any complication, such as a sacculated stone, the condition can be more readily recognized through the high incision, and more understandingly remedied. They say, further, that litholapaxy requires more skill and experience for its safe performance, as well as more complicated and expensive instruments.

These are all theoretical objections, and their value can only be finally established by long experience. The question in the meantime is, not what operation can be most safely entrusted to a tyro, but which operation has the lowest mortality in the hands of qualified surgeons, and under what circumstances is it not applicable, and is another to be selected.

Judging as well as possible from experience thus far obtained, it is the opinion of the most generally recognized authorities in this branch of surgery that litholapaxy is the safest operation in adult patients, and that in children the choice lies between it and lateral lithotomy.

The most important array of cases of supra-pubic lithotomy that have yet been published are those of Dr. Assendelft of Russia. In Langenbeck's *Archiv f. Klin. Chirurgie*, Band xxxvi., 1st and 2d Heft, he publishes the report of 102 cases of supra-pubic lithotomy, with only two deaths. One of the fatal cases he considers due to bronchitis and other troubles not connected with the bladder, and in no way dependent upon the operation, so that he gives his death-rate as about one per cent.

These are the best reported results after supra-pubic incision, and it is therefore important to give them careful consideration. Examining the cases first in regard to age, we find that the patients were all young people. Forty-one of them were under five years of age, twenty-four of them were between five and ten, twenty-nine were between ten and twenty, and only eight were over twenty, the oldest being twenty-eight at the time of the operation.

His cases were all, therefore, of an age at which the best results can be expected from any operation; and although his low death-rate attests his care and skill, it cannot place the high operation above others; for Freyer has achieved the feat of cutting one hundred and forty-three boys by the lateral perineal incision without a death.

Further, we find that in Dr. Assendelft's cases the stones were often very small; in thirty-seven cases they did not reach a drachm in weight. These cases cannot, therefore, be accepted as establishing the death-rate proper to supra-pubic lithotomy, but they give us additional courage to employ this operation when, from the size of the stone or for other reasons, the safer operations are inapplicable.

What are the cases, then, in which the safer operations, litholapaxy and perineal lithotomy, are inapplicable? As has been pointed out in the article on Diseases of the Bladder, in Vol. I. of this HANDBOOK, litholapaxy can be applied to all adult cases of stone, with the following exceptions:

1. A very large and hard stone may resist every attempt at crushing.

2. A stone may have as a nucleus a foreign body, such as a piece of bone or a bullet, too hard to crush, and too large to come through a tube.

3. An encysted stone may be out of reach of the lithotrite.

4. Some writers consider that stricture of the urethra may prohibit litholapaxy. This cannot often happen, for strictures, however close, yield readily to divulsion, which may be immediately followed by the crushing and evacuation of the stone.

5. False passages may exist, which so interfere with the introduction of instruments that the dangers of the operation are greatly enhanced, and the question of lithotomy is to be entertained.

6. The hip may be anchylosed in a position which interferes with the use of instruments through the urethra.

To these might be added two other exceptional conditions pointed out by Dittel:

7. The bladder may shut down so tightly on a large stone that there is no room for the manipulation of instruments.

8. A stone which projects into the urethra, unless it can be dislodged and pushed back into the bladder, cannot be crushed.

When the stone is too large to be crushed, or when a good-sized stone exists in a much contracted bladder, the supra-pubic incision is probably the best operation to select for its removal. Thompson has pointed out that the bruising of a perineal wound by the dragging of a large or rough stone through it, adds greatly to the risk of the operation; and it is better, therefore, when cutting is necessary, to select the high operation for stones of a size to occasion much stretching and laceration along the perineal route.

In the case of an encysted stone the supra-pubic operation has the great advantage that it gives the operator a much better chance than he can get through a perineal opening, to study the condition of things and to meet the difficulties intelligently. It is, therefore, the operation of choice in these cases.

A foreign body, if not large, may be removed by the median perineal incision; but if too large to come safely through the perineum, it should be extracted supra-pubically.

The same may be said of those stones that send prolongations into the urethra. Ordinarily these urethro-vesical calculi are not too large for removal by the perineal incision; and this operation has the decided advantage, that if more calculi are present along the urethra they may be reached and drawn out without any additional incision.

If strictures or false passages seem to make the operation of crushing too hazardous, the choice of the proper cutting method will depend on the size of the stone and the possibility of getting a staff into the bladder. When the urethra is permeable, and the stone is of moderate size, the perineal cut should be made. If, however, the bladder cannot be reached by an instrument large enough to serve as a guide, or when the stone is a large one (two ounces or over in weight), the supra-pubic incision should be resorted to.

An anchylosed hip may so interfere with the management of a guide that the perineal operation is impossible.

and the high operation must be used. When the staff can be used, however, the decision will turn upon the size of the stone.

One other condition remains to be considered which may influence our selection of a cutting operation, and that is, the size and conformation of the prostate. If this gland is so altered in shape that it causes an obstruction to the flow of urine, it may act as a predisposing cause for the formation of stone, and by leading to fermentation of the urine may keep up a constant irritation and inflammation of the bladder. When this is the case it will often be best to select an operation for the removal of the stone which will at the same time enable us to correct the faulty shape of the prostate.

If the stone is small and the prostate of moderate size, we may, by a median operation, dispose of the calculus and at the same time incise or remove the third lobe, which is the obstructing part of the gland.

If the stone, however, is too large for removal by the perineum, the supra-pubic incision must be used. It may occasionally happen, also, that the prostate is so large that it would not be possible, through the perineum, to reach and properly operate on that part which projects into the bladder. In such a case the supra-pubic method would again be the proper one to select, and of the indications for this we shall speak presently.

The Removal of Tumors of the Bladder.—Petersen, in his article on Sectio Alta, which appeared in the *Archiv f. Klin. Chirurgie*, vol. xxv., 1880, in which he reported the first cases operated upon by him with rectal ballonnement, pointed out the applicability of the high operation to the removal of tumors of the posterior bladder-wall, and also suggested the possibility of removing, by supra-pubic incision, a third lobe of the prostate that was obstructing the flow of urine.

It was not long before these suggestions were carried out, and in 1884 Professor Guyon and other French surgeons came out strongly in favor of this operation for the removal of tumors, and pointed out very clearly the advantages of this method over the boutonnière, or median perineal operation, which Thompson had then recently made prominent for these cases.

Although it was not until this time that the applicability of the high operation to all cases of bladder tumor was prominently urged, still it is to be remembered, in the interests of history, that Gussenbauer, in 1876, had reported a case in Billroth's clinic in which a large, solid tumor of the bladder, that had been examined through a perineal incision, was successfully removed over the pubes. Volkmann had also had a similar case later, which ended fatally.

The great and particular advantage of epicystotomy for the treatment of neoplasms of the bladder is, of course, the possibility of seeing the tumor, and acting intelligently for its removal.

As most of these tumors are situated at or about the trigone, it is evident of how great service the rectal ballonnement is in bringing them into view, and into easy reach. For this purpose a pear-shaped bag is perhaps the best, as it lies in the lower part of the pelvis and pushes the floor of the bladder upward toward the pubes.

The technique of the operation is the same as when done for stone, until the bladder is opened. After this the wound may be held apart with retractors, and the posterior bladder-wall thus brought into view. For this purpose long, flat spatulæ of zinc are useful to hold aside the lateral walls, which are pressed in by the intra-abdominal pressure, and make the view of the trigone otherwise impossible. The tumor, when exposed, may be removed with a wire noose or a pair of scissors. If pedunculated, it may be twisted off with a pair of nipping-forceps, and the base from which it grew may be cleaned up with a sharp curette.

Removal of Prostatic Outgrowths.—The cases in which these are properly approached over the pubes are rare. When they can be reached through the perineum this is the better route to select, both on account of the lesser risk to life and because the perineal wound provides better drainage. This last is an important consideration, as in these cases the bladder cavity much resembles a foul abscess.

When, however, the size of the prostate and the depth of the perineum make it impossible to reach the bladder face of the prostate by the boutonnière operation, and at the same time the serious nature of the symptoms from obstruction make some effort for relief necessary, a supra-pubic cystotomy may be resorted to. Occasionally, also, when the bladder has been opened over the pubes for the removal of a large stone, if an obstructing median lobe of the prostate is found, it may be excised without adding greatly to the risks of the operation.

Retrograde Catheterization of the Urethra.—In a few instances of impassable stricture the supra-pubic operation has been done in order to enable the operator to pass an instrument from behind forward to the strictured point, there to cut down upon it from the perineum, and thus open the posterior section of the urethra.

It must happen very rarely that it is not possible with care to follow the urethra backward through the stricture, and thus to accomplish the same object[1] without the added danger of a supra-pubic wound. *A. T. Cabot.*

SYMPATHETIC NERVOUS SYSTEM. To Bichat we owe the conception that the nervous system is composed of two general divisions, differing in their anatomical arrangement and their functions; the one presiding over voluntary motion and perception, the other over involuntary acts and the processes of assimilation and nutrition. The first he called the system of organic life, the other the system of inorganic life. Others have described the latter as the vegetative system, under the impression that it especially presides over nutrition and growth, the so-called vegetative functions; others, bearing in mind its extensive relations throughout the body, have believed that it forms a common bond between remote structures serving to correlate their functions, and have therefore named it the great sympathetic system — a name generally employed. The progress of physiological and anatomical knowledge has somewhat changed this view, and it may be still further modified. For that reason it would be better

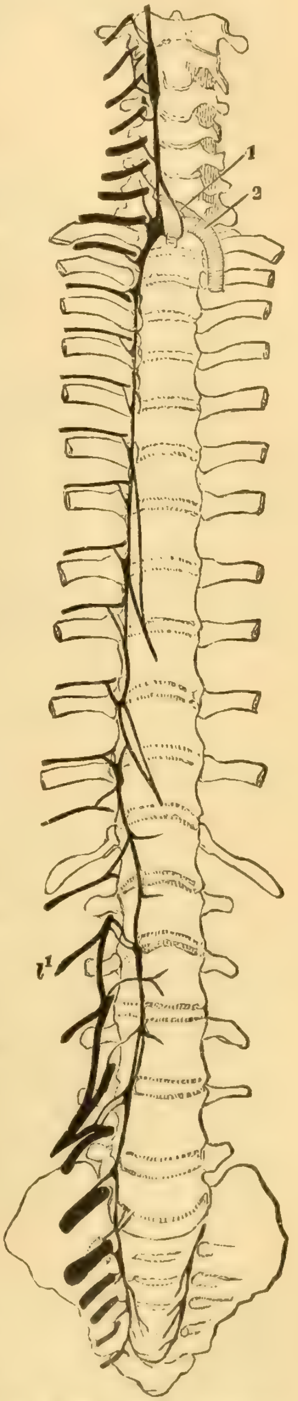

FIG. 5071. — The Interganglionic Cord. 1, Ansa Vieussenii; 2, right subclavian artery.

to adopt some name derived entirely from its anatomical relations or structure. The name that is perhaps to be preferred for the whole system is that of the GANGLIONIC NERVOUS SYSTEM, based upon one of its most significant peculiarities.

The system in question consists of two principal divisions. First, the main trunks or sympathetic nerves, forming two cords lying on either side of the spine, under cover of the ribs in the dorsal region, and near the transverse processes elsewhere, interrupted at intervals by small ganglia which receive branches from the spinal nerves (see Fig. 5071). Second, a system of plexuses accompanying the great vascular trunks and supplying the viscera. At first these plexuses are large meshed, but as they proceed toward the periphery the net-work becomes finer and finer. Interspersed freely among them, usually at the decussation of the fibres, are small ganglia. The terminal branches of the plexuses are sometimes contained within the very walls of the viscera, and the ganglia upon them become microscopic in size. The fibres are usually grayish or non-medullated.

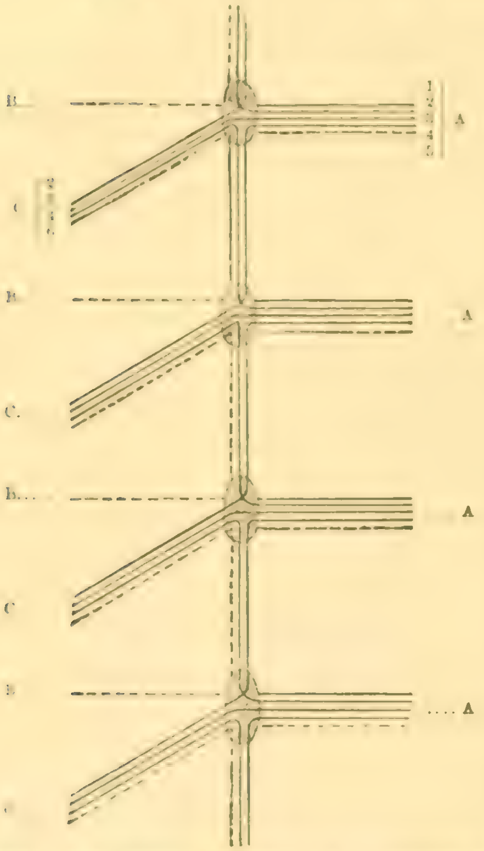

Fig. 5072.—Scheme showing the Formation of the Interganglionic Cord and Distribution of the Fibres of the Sympathetic. A, A, A, A, Fibres passing from the spinal nerves to the sympathetic ganglia. These are seen to be composed of the following classes of fibres: 1, those terminating in the ganglion; 5, those which pass through the ganglion to be immediately distributed to the visceral branches [illegible]; 2, 3, those which pass by means of the interganglionic cord to [illegible] nerves given off from ganglia above or below; these may be considered [illegible] for other ganglia along the cord; 4, [illegible] fibres passing from the ganglion to be connected with the spinal nerves. B, B, B, B, [illegible] to the periphery. C, C, C, C, [illegible] branches of the sympathetic, composed of fibres 2, 3, 4, 6; [illegible] fibres originating from ganglia above or below, and passing up along the interganglionic cord to be distributed with distant visceral branches. It will be noted that the interganglionic cord is made up entirely of fibres 2, 3, and 4, there being no [illegible] fibres having merely a connecting function.

These two grand divisions are connected by several trunks, the principal ones being known respectively, from their terminations, as the cardiac and splanchnic nerves.

The gray fibres of the sympathetic system are evidently of a more primitive type than the more complex medullated fibres constituting the bulk of the cerebro-spinal nerves. They are of the same structure as the first nerve fibres which appear in the fœtus, and resemble those which arise as a new formation in the course of a nerve which has been destroyed. The whole system of plexuses with interspersed ganglia bears a strong resemblance to the earlier types of the nervous system found in invertebrate animals, where there is no cerebro-spinal system proper.

It has therefore been a favorite idea with anatomists to consider the sympathetic system as a species of survival, holding that in the viscera, less exposed to outside influences, there has been less differentiation of structure. This view is supported by many other characteristic features of the viscera. But it should not be forgotten that embryology clearly teaches that the sympathetic system is embryologically identical with the cerebro-spinal, and in no sense such a separate apparatus as might be thought to be implied by this consideration. It is merely a peculiar anatomical arrangement taken on by those branches of the cerebro-spinal system which are distributed to the viscera.

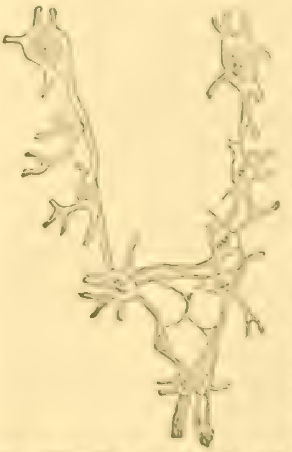

Fig. 5073.—The Ansa Sacralis, with the Last Four Pairs of Sacral Ganglia and the Ganglion Impar. (After Krause.)

Low forms of vertebrates, such as the lamprey (petromyzon), have no sympathetic nerve proper, branches from the spinal nerves passing directly to the viscera. Small ganglia are attached to these visceral branches, apparently arising as segregations from the ganglia upon the spinal nerves. As the viscera become more important and complicated they are supplied by branches from several spinal nerves, and the ganglia from which the branches proceed consequently become more or less interunited by fibres crossing both from below and from above. These cross branches from the interganglionic cord or sympathetic nerve. An examination of Fig. 5072 will show that this cord is entirely a secondary product, composed of filaments which afterward proceed peripherally, none of the fibres being merely internodal in the sense of beginning in one ganglion and ending in another.

The interganglionic cord was formerly supposed to be a cranial nerve, and was known to the elder anatomists as the great intercostal or trisplanchnic nerve. This is not surprising when its mode of origin is known. It is usually considered as commencing at the superior cervical ganglion, which lies at the base of the skull, but branches from this may be traced upward along the internal carotid artery, first as the carotid nerves, and finally as the carotid plexus to the base of the brain. Beclard even carried it so far as the anterior communicating artery, upon which he supposed the nerves of opposite sides to meet, forming at their junction a small ganglion. This is not confirmed by the investigations of recent anatomists. It is much more likely, as will be explained hereafter, that the spheno-palatine ganglion ought to be considered as the superior terminal station of the sympathetic.

The ganglia found upon the cord as it passes down along the spine are evidently segmental in their character. In the dorsal and lumbar regions they correspond to the spinal nerves; in the cervical they are reduced in number, owing to the fact that several of them unite to form single ganglia.

At the lower end of the spine the number of ganglia again becomes irregular. There are usually but four sacral ganglia, and the sympathetic trunks of the two sides are united by means of a loop (ansa sacralis) in a single coccygeal ganglion (G. impar, G. Walteri, Fig. 5073).

The connection of the various ganglia with the spinal nerves is shown in Figs. 5074 and 5075, but the details of the connection are diagrammatically given in Fig. 5076, from which it will be seen that fibres pass from both the posterior root (spinal ganglion) and anterior root of each spinal nerve to the ganglion of the sympathetic, and that this in turn gives off branches which pass to both the anterior and posterior branches of the spinal nerves, as well as a visceral branch and another small twig which, uniting with a similar one from the spinal ganglion, forms the nervus sinu-vertebralis of Luschka, which takes a recurrent course, passing back through the intervertebral foramina into the spinal canal, where it supplies the membranes of the cord. In the cranium this nerve is represented by the various recurrent branches given off from the three great divisions of the trifacial and the recurrent branch of the pneumogastric, also known as the posterior meningeal nerve or ramus duræ matris.

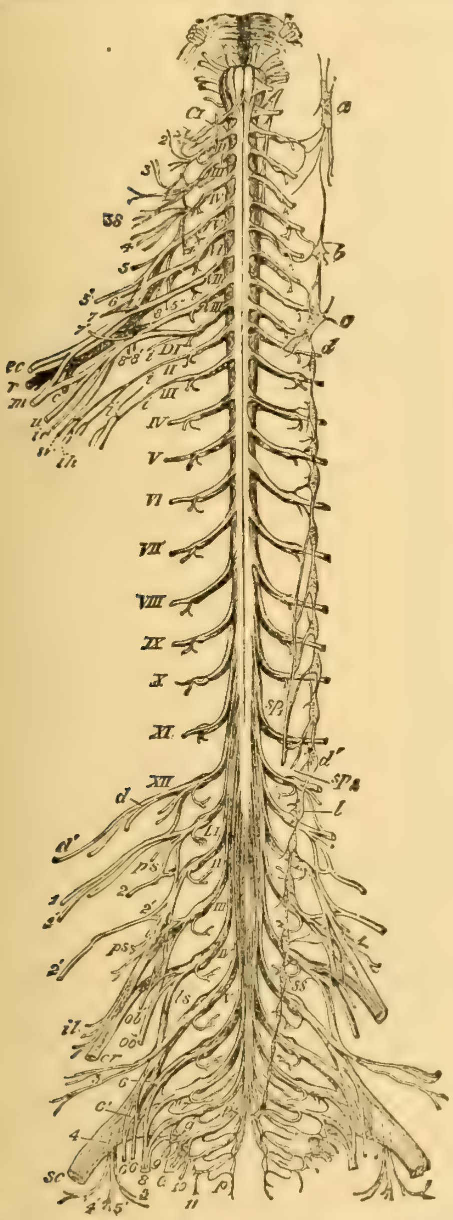

FIG. 5074.—Diagram showing the Spinal Cord from before, with the Attachment of the Principal Nerves. On the right-hand side of the diagram the connections with the sympathetic nerve are shown: on the left-hand side, the plexuses of the anterior roots. (From Ferrier.)

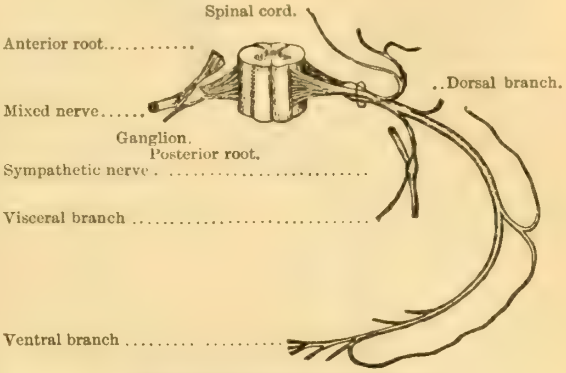

FIG. 5075.—Diagram of a Spinal Nerve.

The typical arrangement of the ganglia and the connecting cord is subject to considerable variation, there being often two or more strings instead of one passing from one ganglion to another. The cord sometimes fails altogether. Ganglia may be fused together, or there may be more than the usual number, caused by the separation of small masses from the main body.

In structure the sympathetic ganglia are markedly different from the spinal ganglia, from which they are believed to originate. The nerve-cells which they contain are, in higher vertebrates, multipolar and pigmented, there being none of those peculiar unipolar cells with dividing fibres which are characteristic of the spinal ganglia. Each cell has an investing membrane which is continued upon the processes and probably becomes eventually the sheath of the nerve-fibres. Unlike the spinal ganglia the number of efferent fibres considerably exceeds that of the afferent. Although not certainly known, it is believed that all the processes of the cells end in non-medullated nerve-fibres.

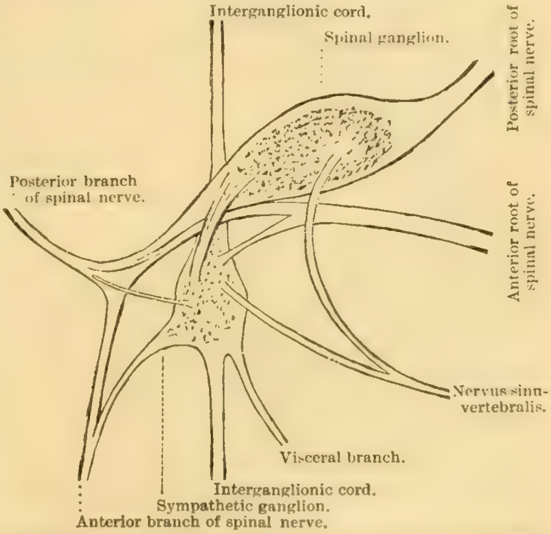
Interganglionic cord.
Spinal ganglion.
Posterior root of spinal nerve.
Posterior branch of spinal nerve.
Anterior root of spinal nerve.
Nervus sinu-vertebralis.
Visceral branch.
Interganglionic cord.
Sympathetic ganglion.
Anterior branch of spinal nerve.

FIG. 5076.—Diagram showing Connections of a Sympathetic Ganglion.

The ganglia appear, therefore, to be veritable relay-stations connected with the cerebro-spinal system by means of medullated nerve-fibres and giving off non-medullated fibres, passing both with the spinal nerves and by their own visceral branches peripherally. It should be remembered that a considerable number of medullated nerve-fibres pass from the spinal nerves directly through the ganglia and are distributed with the others (see Fig. 5077). Each ganglion has an investment of connective tissue in all respects similar to that of the spinal ganglia.

The peripheral fibres of the sympathetic appear to have a great variety of functions. They are believed not only to be sensitive (the sensation conveyed being of an ill-defined character), but also motor, as shown in the heart. As a peculiar case of the latter may perhaps be classed the vaso-motor fibres which control the smooth muscles of the vascular system, and cause many of the phenomena connected with the nutrition of the parts to which the vessel is distributed. Formerly certain fibres (trophic fibres) were believed to have a direct control of the nutrition of certain organs. It appears more probable at present that these are merely vaso-motor fibres. More obscure are the functions of fibres described as *secretory*, and others as *inhibitory*. The former act directly upon the glands, increasing their activity; the latter restrain the action of the glandular and other organs. There is much that is yet very obscure as to the anatomical distinction and termination of the various fibres.

Fig. 5077 gives a diagrammatic statement of the upper cervical and cranial portion of the sympathetic, together with its connection with the cranial nerves.

The superior cervical ganglion (42), also called the cranio-cervical ganglion, receives branches of communication from the glosso-pharyngeal, pneumogastric, and hypoglossal nerves of the cranium, and the first four cervical nerves. It must therefore be considered as arising from a fusion of those segments of the sympathetic relating to the metameres of the vagus group and the first four cervical metameres.

Considerable discussion has arisen as to whether the sympathetic cord can be traced further upward to the region of

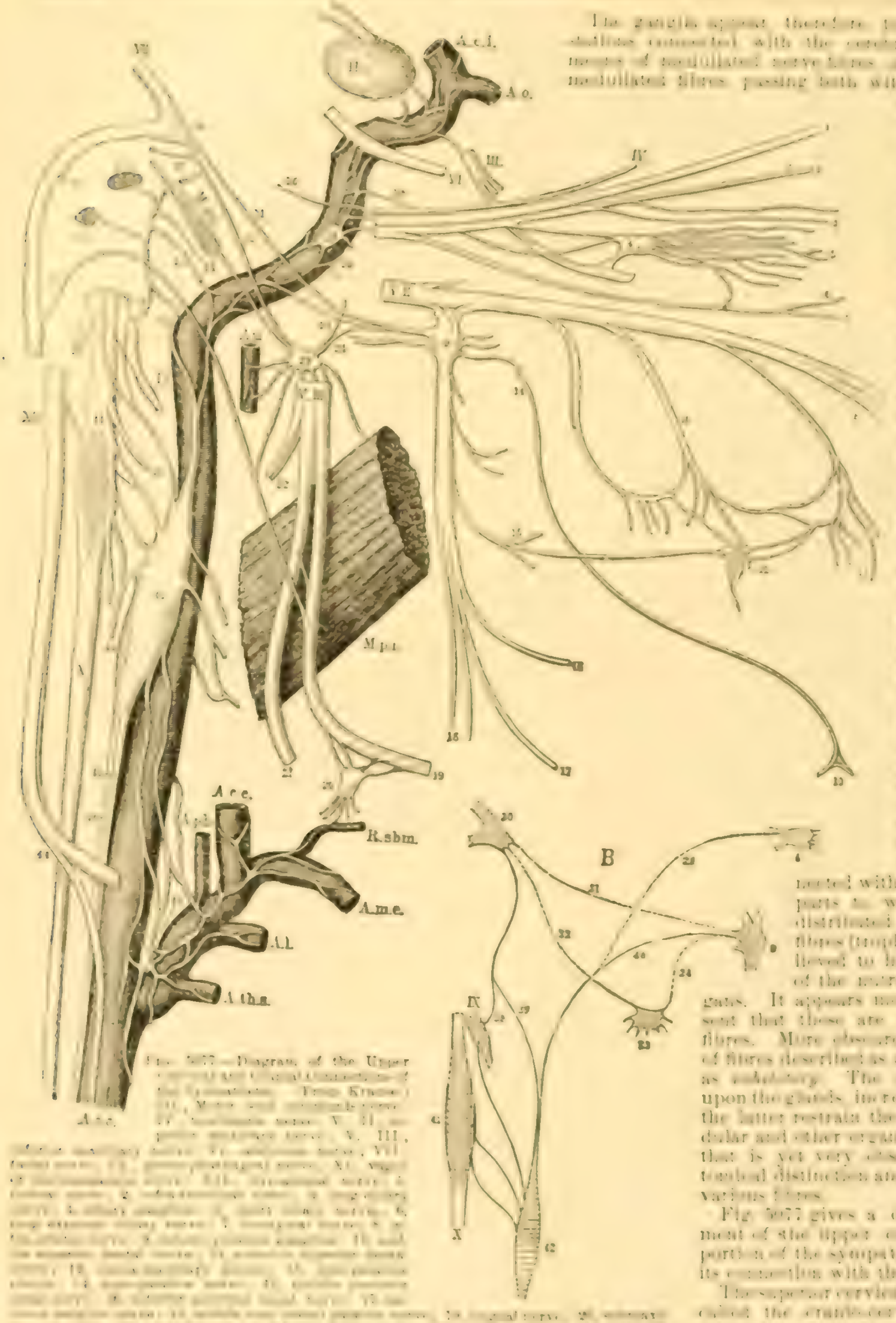

Fig. 5077.—Diagram of the Upper Cervical and Cranial Connections of the Sympathetic. (From Krause.) III., Motor oculi (oculomotor) nerve; IV., trochlearis nerve; V. II., superior maxillary nerve; V. III., [illegible]

the trigeminus. The direct continuation of the cord is by the carotid nerves and plexus. Connecting with the carotid plexus, or with its continuation the cavernous plexus, are branches derived from the third, fourth, fifth, and sixth cranial nerves, that is to say, the trigeminus group. Some anatomists call these the anterior superior roots of the sympathetic, the connections of the superior cervical ganglion with the vagus group as the posterior superior roots, and those with the spinal nerves as the inferior roots.

One of the principal branches of the carotid plexus is the great deep petrosal nerve (25), a branch of the Vidian, which passes to the spheno-palatine ganglion (9). This ganglion possesses the connections of a regular segmental ganglion of the sympathetic, and gives off visceral branches distributed to the pharynx. The view held by Meckel, that it was the highest member of the segmental ganglia of the sympathetic, was, therefore, probably correct. Since we are here at the last of the series, the internodal cord is reduced to a minimum.

Of the other ganglia of the cranium connected with the sympathetic, the ciliary, otic, and submaxillary are to be considered as peripheral ganglia. They contain the characteristic multipolar cells of the sympathetic ganglia. The ganglia of the pneumogastric and glosso-pharyngeal nerves, the geniculate ganglion of the facial, and the Gasserian ganglion, all contain unipolar cells, and are to be reckoned as spinal ganglia.

It is to be noted that each of the above-named sympathetic ganglia has connections with a motor and a sensory nerve as well as with the sympathetic. These connections are known as the roots or radices of the ganglia, or, respectively, as the radix motoria, radix sensitiva, and radix sympathetica.

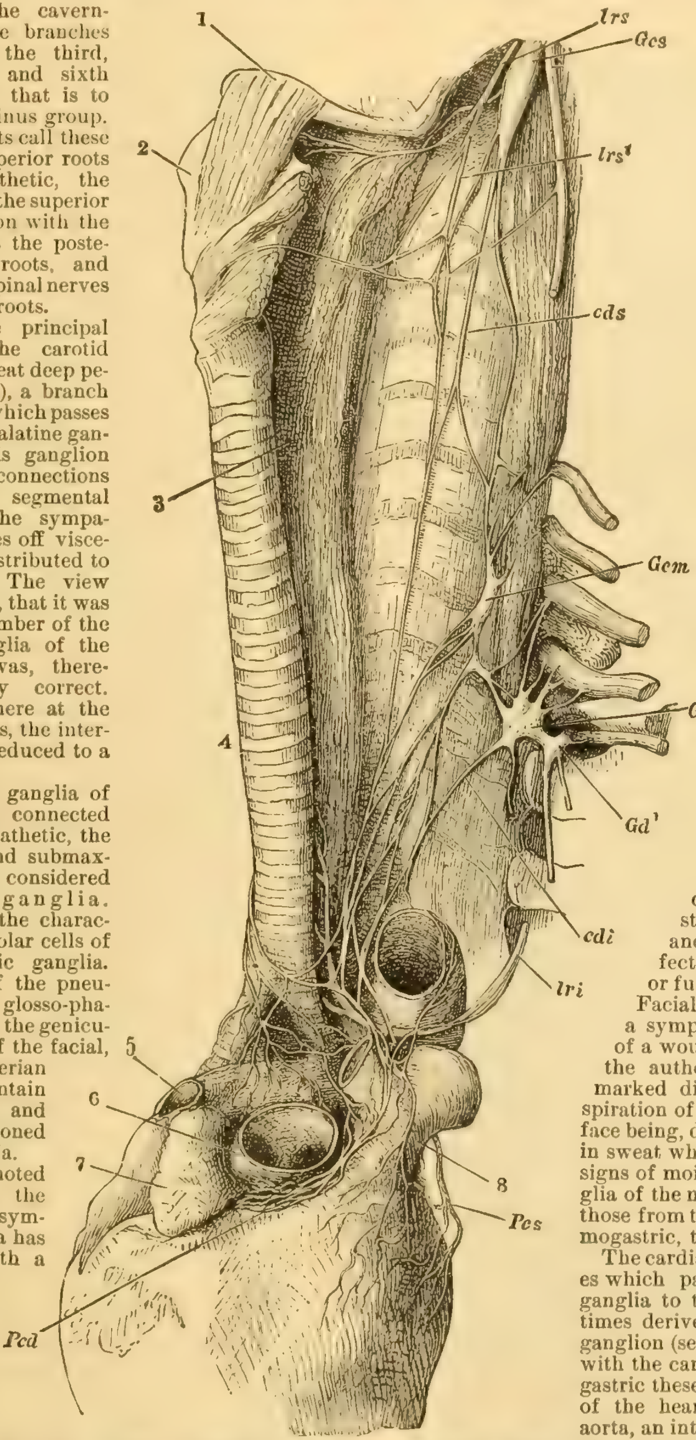

FIG. 5078.—Cervical Sympathetic Ganglia and the Cardiac Nerves. (Henle.) 1, Hyoid bone; 2, larynx; 3, œsophagus; 4, trachea; *lrs*, superior laryngeal nerve; *lrs'*, external laryngeal nerve; *lri*, lower end of inferior laryngeal nerve; *Gcs, Gcm, Gci*, superior, middle, and inferior cervical ganglia; *Gd'*, first thoracic ganglion; *cds, cdi*, superior and inferior cardiac nerves; *Pcd, Pcs*, coronary plexuses; 5, superior vena cava; 6, aorta; 7, right auricular appendage; 8, pulmonary artery.

A number of minute inconstant ganglia have been described by different authors. Such are the carotid ganglion of Krause (No. 27, Fig. 5077) in the carotid plexus; the temporal ganglion on the external carotid artery, which appears to have a relation to the parotid gland like that which the submaxillary ganglion has to the submaxillary gland.

Branches from the superior cervical ganglion form plexuses on the external carotid and its branches. The inter-carotid ganglion (Fig. 5077, No. 47) is not now considered as nervous in its character, but rather as a vestige of atrophied branchial vessels.

The other ganglia of the neck are shown in Fig. 5078. The middle cervical ganglion (*Gcm*) is situated near the sixth cervical vertebra and the inferior thyroid artery. It connects with the fifth and sixth cervical nerves. Occasionally it is absent. It sends a plexus to the inferior thyroid artery. Opposite the transverse process of the seventh cervical vertebra, or a little below, is found the third cervical ganglion (*Gci*), often united with the first thoracic. It sends a plexus to the subclavian artery, usually passing a loop around it (ansa Vieussenii, Fig. 5071). The position of the sympathetic cord being quite deep, it is rarely injured. In some cases it has been severed by a stab or pressed upon by tumors, and this is sometimes found to affect in some manner the nutrition or functions of that side of the face. Facial hemiatrophy is thought to be a sympathetic neurosis. In one case of a wound on the side, coming under the author's observation, there was a marked difference in the amount of perspiration of the two sides—one-half of the face being, during hot summer days, bathed in sweat while the injured side showed no signs of moisture. Branches from the ganglia of the neck pass to form, together with those from the glosso-pharyngeal and pneumogastric, the pharyngeal plexus.

The cardiac nerves are peripheral branches which pass from each of the cervical ganglia to the heart, a branch being sometimes derived also from the first thoracic ganglion (see Fig. 5078, *cds, cdi*). Uniting with the cardiac branches of the pneumogastric these nerves form, around the base of the heart and under the arch of the aorta, an intricate plexus (plexus cardiacus, plexus aorticus superior), usually divided into a superficial portion in front of the aorta and a deep portion behind and below, the latter being the larger. From this plexus offsets pass to the coronary arteries, along the descending aorta, the pulmonary arteries, and bronchi, to take part in a second great plexus, the pulmonary, also formed by union with the pneumogastric. It is continued along the œsophagus. Filaments from the cardiac plexus pierce the wall of the heart supplying its substance, many microscopic ganglia being developed in their course. Among the most important of these is the ganglion of Wrisberg, about the centre of the plexus. In the frog the ganglia within the substance of the heart have been noticed to have special functions, and to insure the beating of that organ after its nervous connections are severed. Indeed it appears clear, from numerous and varied experiments that have been made on this subject, that the principal controlling agency of the movements of the heart lies in these little ganglia. Bearing in mind this fact we are able to understand why a comparatively slight cause may sometimes at once arrest permanently the heart's action. The doctrine sometimes taught that a puncture even into the heart's substance may be made with a fine trocar is surely extremely dangerous, as it is well known that a lesion of some of these ganglia is at once fatal. The ancients supposed the main seat of the emotions to be in the heart itself, and the obscure sensation of oppression in the cardiac region caused by depressing emotions is popularly recognized in many ways.

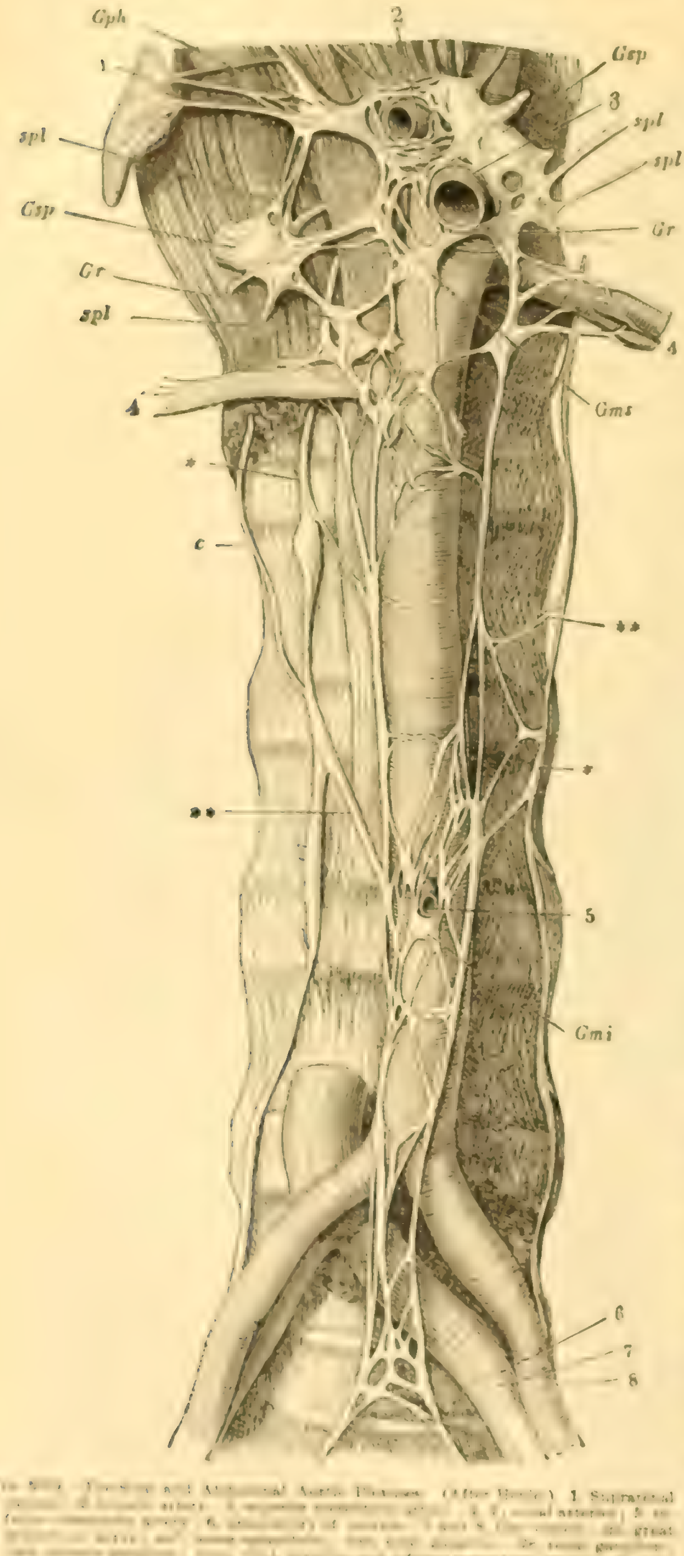

Fig. 5079.—Thoracic and Abdominal Aortic Plexuses. (After Henle.) 1, Suprarenal [illegible] renal arteries; 5, in[illegible] great [illegible]

The thoracic ganglia usually equal in number the body segments in this region. The upper ones give off branches which reinforce **the aortic, pulmonary,** and œsophageal plexuses (aortico-pulmonary branches). From the lower nerves are given off the great branches known as the splanchnic nerves which penetrate the diaphragm and supply the abdominal viscera. In appearance they resemble the cerebro-spinal nerves, being white rather than gray, owing to a predominance of medullated fibres.

The great splanchnic nerve is formed by peripheral branches derived from the sixth, seventh, eighth, and ninth thoracic ganglia. The lesser splanchnic is derived from the tenth, eleventh, and twelfth thoracic ganglia. The lower root sometimes remains independent and is then known as the renal splanchnic (nervus splanchnicus imus inferior or tertius—posterior renal nerve of Walter). Occasionally a splanchnic nerve is formed from the upper thoracic ganglia or from the cardiac plexus (nervus splanchnicus supremus). **These nerves penetrate the diaphragm** through either the crura or the aortic opening, and pass to a large, wide-meshed plexus situated in front of the aorta immediately under the diaphragm.

This, known under various names as the solar plexus, cœliac plexus, epigastric plexus, nervous centre of nutritive life, cerebrum abdominale, is by far the most considerable plexiform structure in the body, forming by its connections interlacements which embrace **all the great** vascular trunks of the abdomen and supply all the viscera therein contained. Fig. 5079 shows only a part of it that is in immediate relation with the aorta and its branches. Many ganglionic masses are collected at the points of intersection of the meshes. These, known as the solar ganglia, are quite irregular and variable in size and volume. Two principal masses can usually be made out on either side of the cœliac axis, having a somewhat crescentic shape, and hence known as the semilunar ganglia.

Secondary offsets proceed from this plexus upon all of the **principal trunks of the** abdomen, receiving names according to the trunk upon which they are situated. Thus we have phrenic, gastric, hepatic, splenic, superior mesenteric, renal, suprarenal, spermatic, and ovarian plexuses. Ganglionic masses within these sometimes receive special

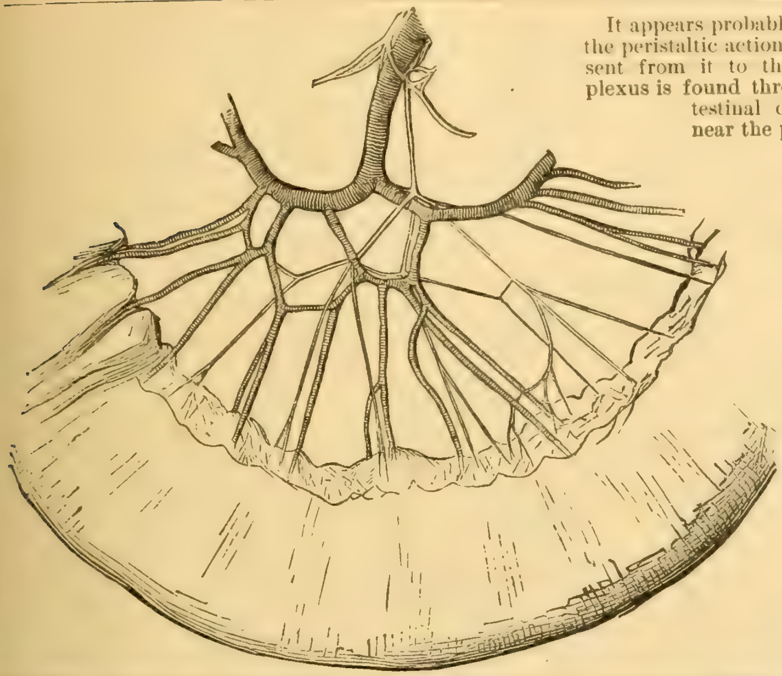

FIG. 5080.—A Portion of the Small Intestine, showing the Distribution of a Twig from the Mesenteric Plexus. (Henle.)

names, as the phrenic, superior mesenteric, and renal ganglia.

The solar plexus is continued downward along the aorta as the abdominal aortic plexus, plexus lumbo-aorticus or intermesentericus, and from this an offset proceeds to the inferior mesenteric artery. Still farther downward, in front of the last lumbar vertebra, the aortic plexus is known as the hypogastric plexus; and continued downward into the pelvic cavity in front of the sacrum, as the inferior hypogastric; it gives offsets along the branches of the internal iliac artery, receiving from them distinctive names.

These latter plexuses are exceedingly close-meshed, and abound in minute ganglia. Being intimately connected with the genito-urinary organs they play a very important rôle in the phenomena of generation and nutrition. Many of the protean symptoms of pregnancy are caused by pressure upon these nerves or interference with their functions.

Peripheral branches proceed from the abdominal and pelvic plexuses to the viscera. Those for the intestine usually pass within the folds of the peritoneum in the manner shown in Fig. 5080. While within these folds many of the branches have upon them Pacinian corpuscles, which is thought to be evidence as to their sensory character. Within the walls of the intestine the nerves again unite to form intricate plexuses. One lying between the layers of longitudinal and circular muscular fibres is known as the plexus myentericus externus (Auerbach's plexus). A clear idea of this curious structure can be had on consulting Fig. 5082. It appears probable that to this plexus is mainly due the peristaltic action of the intestines. Fine fibrillæ are sent from it to the muscle fibres themselves. This plexus is found throughout the entire extent of the intestinal canal, commencing in the stomach near the pyloric orifice.

Another plexus is found within the intestinal wall, communicating with Auerbach's plexus and lying under the submucosa (see Fig. 5081).

This was discovered by Meissner, and is known frequently by his name, but also as the plexus myentericus internus, or plexus intestinalis submucosus. It is wider meshed than Auerbach's plexus, and has collections of ganglionic cells at the intersections. It also extends throughout the small and large intestine. It apparently controls the small vessels and the smooth muscle fibres of the mucous membrane.

The nervous supply of the uterus has been very carefully investigated. The offset of the inferior hypogastric plexus that extends along the uterine and vaginal vessels is known as the plexus utero-vaginalis. At the fundus of the vagina there is found a considerable ganglionic mass, surrounding the cer-

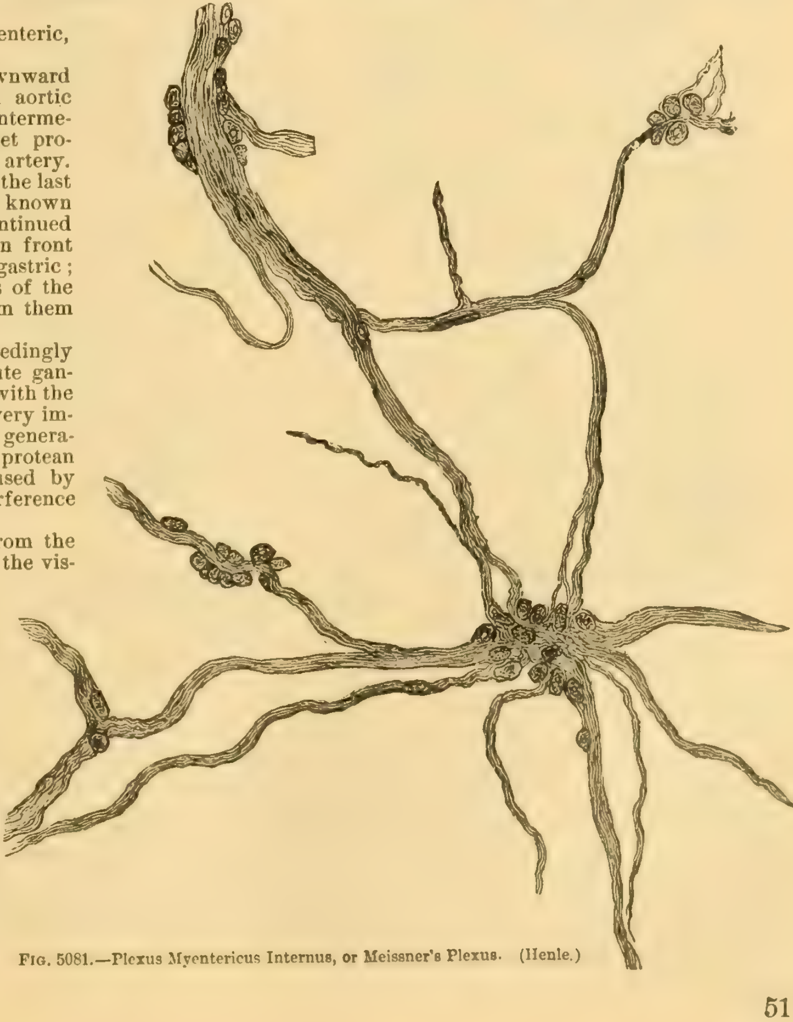

FIG. 5081.—Plexus Myentericus Internus, or Meissner's Plexus. (Henle.)

vical portion of the uterus, and known as the cervical ganglion. From this are derived all the nerves supplying the lower portion of the organ. While they form plexuses within its mass between the muscular sheets no ganglia are found there. During pregnancy they greatly increase in length and thickness. *Frank Baker.*

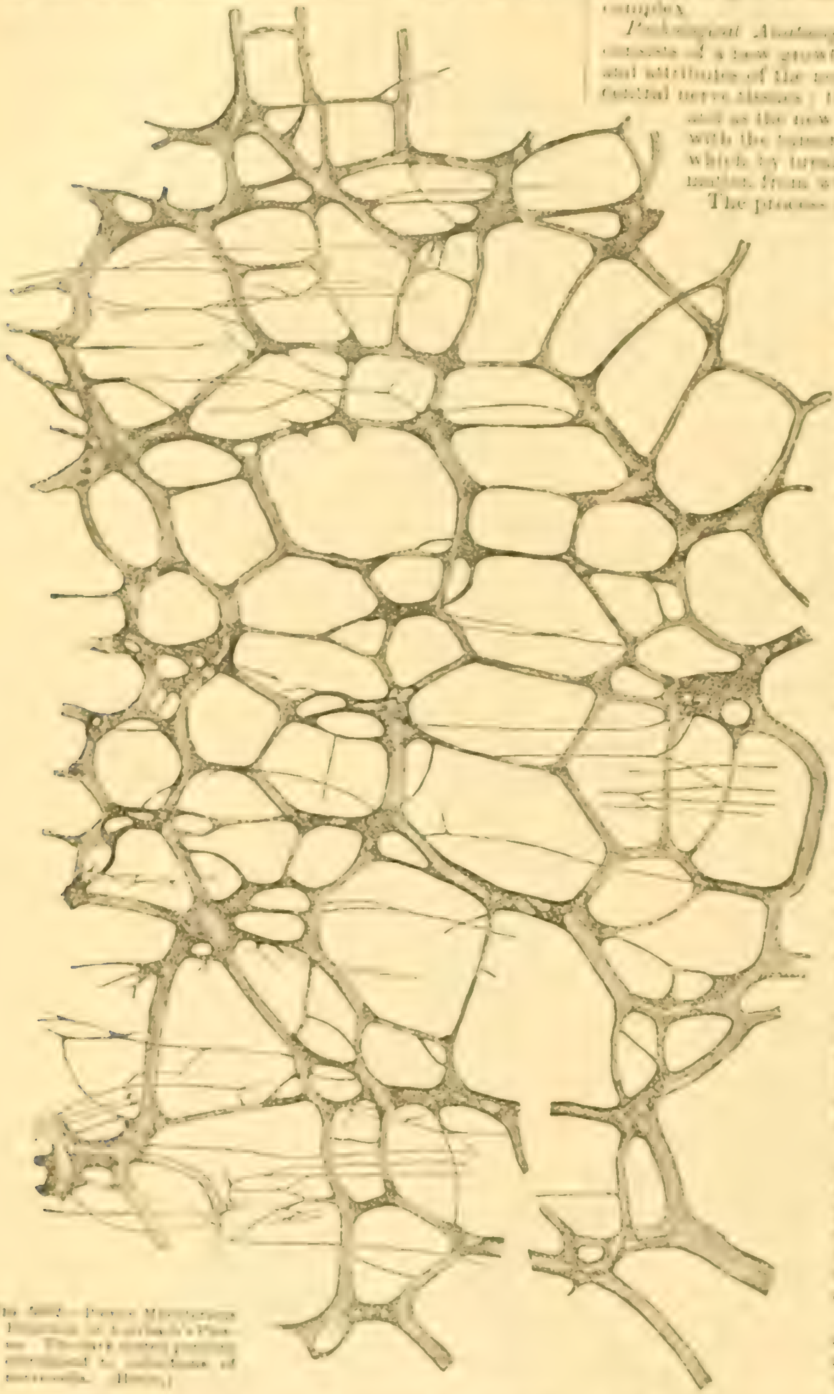

Fig. [illegible].—[illegible] Plexus, or Auerbach's Plexus. [illegible] surrounded by collections of [illegible]. (Henry.)

SYRINGO-MYELIA.

SYRINGO-MYELIA. Syringo-myelia (Ger. and Fr., Syringomyelie, from the Greek σύριγξ, a cavity, and μυελός, marrow, or pith) means, literally, any abnormal cavity in the spinal cord; it has, however, acquired a narrower meaning, and is now only used to designate cavity formation which is pathological, and accompanied by a growth of new tissue; there is in lesions of this kind such uniformity in seat and mode of development as suffice to give in most cases a well-defined symptom-complex.

Pathological Anatomy.—The lesion in syringo-myelia consists of a new growth of tissue, having the structure and attributes of the normal supporting substance of the central nerve tissues; that is, it is essentially glia tissue, and as the new growth may properly be classed with the tumors, the lesion is really a glioma, which by breaking down causes the cavity formation from which the disease is named.

The process may begin in the white or in the gray matter, and is in either case central; it reaches the pia mater, if at all, late in the course of the disease. In the majority of cases the point of origin is in the neighborhood of the central canal, which latter may remain separate from the new cavity during the whole course of the disease, or, more often, sooner or later unites with it as a result of a breaking down of the intervening tissue; it differs in this respect from hydromyelus, a condition found early in life, which consists in a distention of the central canal; the latter is the result of a congenital defect of development.

The new tissue is formed through a considerable extent of the spinal cord, and does not result in a transverse lesion; it may form in places enlargements of well-defined proportions, but has, as a rule, the characteristics of an infiltrating growth, and this hyperplastic appearance has led some observers to class the disease with the chronic inflammations. The growth may begin in any part of the vertical extent of the cord, but in most cases originates in the lower cervical and upper dorsal segments, and may extend as far as the medulla oblongata.

In some cases there are curvatures of the spinal column, which, except in cases in which there has been a trauma, seem to be due to muscular abnormalities rather than to disease of the vertebra.

The cord, on removal from the canal, may appear normal; it is often enlarged in the affected portions; if the process has extended to the periphery the pia mater may be adherent; there are rarely gliomatous masses in connection with the meninges.

On section, the cord at the affected part is soft, and contains a cavity of greater or less extent, which may, late in the disease, extend entirely across the cord in the lateral direction, so as to separate the anterior and posterior portions. The contents of the cavity are serous or gelatinous, and usually escape as soon as the cord is cut into. The preserved portions of nervous tissue have approximately a normal appearance.

On microscopical examination the cavity is seen to be bordered by tissue consisting of a fine fibrous net-work abundantly supplied with nuclei; the cell bodies are very delicate, and not easily seen. The tissue is well supplied by blood-vessels with thin walls, and there are often hæmorrhages and blood-cysts which may be of considerable size. There is no sharp line between the new growth and the normal tissue, but along the edges there is an infiltration of the nervous elements with cells, which do not differ in appearance from those of ordinary glia tissue.

The nerve-structures undergo the usual changes consequent on pressure, that is, atrophy, disintegration, and absorption; they often exhibit considerable tolerance of the presence of the new tissues, as in a case described by Schultze, in which the ganglion cells of an anterior horn were flattened out so that they lay with their axes all in a transverse direction, but otherwise appeared normal. (How much of this was really due to the disease process is somewhat doubtful; the ganglion cells of the cervical portion of the normal cord are often seen to be arranged in this way, possibly from the same cause which produces a flattening of the whole cord in this region.) The ganglion cells finally lose their processes, become shrunken, undergo pigment degeneration, and are absorbed. The axis-cylinders may become swollen and varicose, or may simply atrophy; granule-corpuscles are often abundant.

Secondary degenerations are frequent, being especially common in the lateral pyramidal tracts; they present the usual histological alterations; in some cases system degenerations have been described, which could not be due to cutting of the tracts by the new growth; thus, in a case described by Strümpell, the lateral pyramidal and direct cerebellar tracts were degenerated, but at no point affected by the primary lesion; unfortunately the medulla was not examined, so that it remains uncertain whether or not the pyramidal fibres were in this case affected above the level of the neoplasm.

Symptoms.—These depend on the location of the new growth, and on the extent and duration of the process. The first variations from the normal are noticed, in most cases, in the upper extremities, and vary according as one or another set of nerve-fibres or cells is first involved; but the cavity may be situated so as to give no symptoms, at least such as to make a correct diagnosis possible. It was first pointed out by Schultze, of Heidelberg, that many of these cases may be recognized during life.

The motor symptoms consist in progressive paralysis, accompanied in the upper extremities, if the disease is in the cervical region of the cord, with atrophy and the reaction of degeneration, diminished or abolished reflexes, and often with fibrillar twitching; as a rule, groups of muscles which habitually act together are affected at the same time; no special group of muscles is affected by preference. Somewhat later there is apt to be progressive weakness of one or both legs, with exaggerated reflexes, differing in no way from spastic paraplegia due to other causes. If the disease extends to the medulla, the face, tongue, and pharynx may be wholly or partially paralyzed. All of these paralyses are usually slowly progressive in character, but in exceptional cases power may be entirely lost in a particular group of muscles very rapidly, even within a few hours, as if from a sudden breaking down of tissue.

Sensory symptoms consist of pricking and burning sensations and formication, rarely, if ever, true lancinating pains. Much more important is anæsthesia, which is almost invariably found; the loss of sensation does not usually extend over a very large area, but occurs in patches on the body or limbs, or occasionally a whole limb may be anæsthetic; the loss is almost always to impressions of pain and of temperature, with tactile sensibility almost or quite normal. The affected area of skin may be entirely insensitive to heat or cold, receiving only a tactile impression from a hot or cold object; in some cases there is added a peculiar kind of hyperæsthesia, so that a very moderate degree of heat or cold may cause the patient great pain, without his being able to distinguish it from other painful impressions; this paræsthesia may be combined with delayed sensation, so that the patient may cry out with pain some time after the offending object has ceased to be in contact with the skin. The anæsthetic areas do not usually coincide in nerve-supply with the paralyzed muscles.

Trophic changes are noticeable, and may be the first symptoms to attract attention; there are often spontaneous and painless fractures of bones, erythematous and phlegmonous inflammations, œdema either of the skin alone or also of the deeper structures, and ulcers; in addition, increased sweating, local coldness and cyanosis, and sometimes attacks of dizziness, which, as well as the preceding symptoms, are to be attributed to vaso-motor disturbances.

When the disease extends toward the medulla, there are apt to be sensory disturbances in the area supplied by the trigeminus; diabetes insipidus has been noted in some cases. Paralysis and anæsthesia may in any case be preceded by transient spasm and hyperæsthesia, respectively. Sexual activity is apt to be lessened or abolished. The bladder and rectum may suffer either from involvement of their centres in the lower part of the cord, or more often by the severing higher up of the fibres which connect these centres with the brain. Optic atrophy and transient paralyses of the eye muscles have sometimes been observed; to what these are due is not clear. Other cerebral symptoms are usually absent.

Course and Duration.—The progress of the disease is slow, often requiring from two or three to ten years before death ensues; there are in many cases marked remissions, during which the general health improves, and the motor and sensory symptoms cease to progress, and even sometimes become much less marked. Death, however, inevitably results, and may be caused by any of the ordinary complications of spinal-cord disease, pneumonia, œdema or gangrene of the lung, paralysis of the muscles of respiration, bed-sores, cystitis, and pyelitis, or from exhaustion with heart failure.

Diagnosis.—It should be remembered that none of the symptoms of syringo-myelia are in any sense pathognomonic; they simply furnish an indication that there is a slowly progressive lesion of the central tissues of the cord. Experience has shown that such a lesion is almost invariably gliomatous, with cavity formation, just as it is found that a lesion confined to the posterior columns is almost certainly sclerotic, and so on.

A good deal of confusion has been caused in nomenclature of diseases of the cord, by the publication of cases the diagnosis of which has not been verified by autopsy. In this way many anomalies have been described, especially in cases referred to the group of progressive muscular atrophies, from the fact that sensory symptoms were not given sufficient weight in forming a diagnosis.

There are a few diseases of the nervous system which are of protean type, and may appear in almost any guise. Of these hysteria was the earliest to attract attention, and formerly most nervous cases whose symptoms could not be accounted for in any other way were brought under this head. It may be taken for granted that syringomyelia, except in the very earliest stages, will present objective symptoms which indicate organic disease with certainty; in most cases there is paralysis with atrophy and the reaction of degeneration; if this is not found, there are trophic changes much more marked in character than are those which accompany a purely functional disturbance; several cases without paralysis are recorded, in which the diagnosis was made simply from the occurrence of painless spontaneous fractures of bones, and sensory disturbances of the kind indicated above; in one of these cases, reported by Schultze, the diagnosis was verified by autopsy.

Multiple sclerosis has of late years been studied very carefully, and the infinite variety of its lesions in position and extent recognized; it is conceivable that a sclerotic patch might occupy the central portion of the cord, and so cause the symptoms which are regularly found in syringo-myelia; at the same time I know of no such case on record, and the chances against its occurrence would in any particular case be very great.

The habit of omitting examination of the peripheral nerves at the autopsy of cases of suspected disease of the central nervous system is in great part the reason why we know so little of primary and secondary nerve affections; a routine naked eye and microscopical examinathat of the different nerve-trunks in cases of this kind cannot be too strongly insisted on. Multiple neuritis has but lately attracted the attention it deserves. In typical cases it is readily differentiated from syringo-myelia by its rapid course, marked pain and tenderness along the nerve-trunks, paralysis coinciding in distribution with the areas of sensory disturbance, and equal involvement of the tactile with the other varieties of the sense of touch. At the same time it must be said that affections which are now classed with the neuritic processes may give only motor symptoms, as in lead palsy, or only sensory symptoms, as with some of the neuralgias of organic origin, so that there would seem, in mixed nerves, to be a selective action in disease analogous to that which is found in system diseases of the spinal cord. Again, some of the neuritic processes are doubtless subacute or chronic, and may correspond to the primary degenerations in the cord and brain. Until the different forms of nerve disease have been more carefully studied and classified it will be impossible to lay down fixed rules for their differentiation; but it will be possible to distinguish syringo-myelia from most of these forms of disease on the general principles already laid down, and especially from the somewhat striking fact that the motor and sensory symptoms in this affection are apt to be dissociated, and not to occur in the distribution of the same nerve.

Against confusion with the diseases mentioned above a careful routine examination is the only safeguard, as some important symptoms, especially anæsthesia, may be unknown to the patient and unsuspected by the physician. It is somewhat easier to distinguish the disease in question from those affections which have a definitely located lesion. Of these the progressive muscular atrophies form a distinct class, and may readily be excluded in any doubtful case by establishing the existence of sensory symptoms. Under this head may properly be brought the various forms of pseudo-hypertrophy, which are without doubt varieties of the same disease, progressive muscular atrophy of spinal type, amyotrophic lateral sclerosis, and acute and chronic polio-myelitis anterior. Without discussing here the relation which these diseases bear to one another, we will observe that they are alike in one respect: in any uncomplicated case sensory symptoms must, from the position of the lesion, be entirely absent.

A mistaken diagnosis of locomotor ataxia could hardly be made, except in those cases of syringo-myelia in which the new growth begins in the posterior columns; in this case, however, the columns of Goll are affected sooner than are the root zones, and the typical character of the anæsthesia, origin of the disease in the cervical region, and lack of eye symptoms, will serve to distinguish the case from one of tabes. In general, such disease processes as tumor, and cavity formation, and ordinary inflammatory action have a certain irregularity of development, no matter where they begin, and differ markedly from the system diseases, which, beginning in certain tracts of fibres, run almost or quite their entire course without overstepping the limits of these tracts; so that it is possible to give of the system diseases a clinical picture which shall much more accurately correspond to the features of any particular case. At the same time, even with such a process as the one under discussion, there is a strong tendency for the lesion to occupy a definite position, and it is this fact which makes its diagnosis possible.

Hypertrophic pachymeningitis and meningeal tumor are distinguished by the early occurrence of marked pain and tenderness over the affected region, and absence of the symptoms which are caused by lesion of the central part of the cord; but in cases of syringo-myelia with gliomatous masses in the meninges, the diagnosis may be difficult or impossible.

Frequency and Causation.—This disease was formerly considered quite rare, because unrecognized; it was usually diagnosed as progressive muscular atrophy, tumor of the cord, or spastic paralysis. It is said by Schultze to be as common as multiple sclerosis. While this may be true in Germany, it can hardly hold good in this country; the diagnostic features of the disease are moderately well known here; the only case yet on record in the United States was described by Dr. M. Allen Starr in the *American Journal of the Medical Sciences* for May, 1888; while not verified by autopsy, the diagnosis is conceded to have been a correct one. Twice as many men as women are said to be affected by the disease. It occurs most often between the ages of thirty and forty years.

Little is known of the causation of syringo-myelia; in a moderate proportion of the cases there is a history of preceding trauma, with injury of the spinal column or of the cord itself. It has been thought by some writers that the disease invariably develops in a cord predisposed by congenital defects; this is denied by Schultze, who holds that the changes may commence in an originally healthy cord, and as well in the white as in the central gray matter. Exposure to cold, and venereal and sexual excesses may probably be excluded as causative agents in this disease.

The prognosis is absolutely bad. No case of recovery is on record.

Treatment is confined to the relief of symptoms and sustaining of the general health; no specific against the disease process is known.

Henry S. Upson.

TEA (*Thé*, Codex Med.). The prepared leaves of *Thea sinensis* Linn. (*Camellia Thea* Link, etc.), Order, *Ternstrœmiaceæ*. This includes as varieties *Thea (Camellia) viridis*, *Th. Bohea* and others, as well as the wild Assam Tea tree supposed to be the origin of them all. The Tea plant as seen under cultivation is a shrub a metre or so in height (from two to five feet), but in the wild state it becomes a small tree of from five to ten metres. It has bushy, very leafy branches and smooth, brown bark. The leaves are alternate, evergreen, rather thick and leathery, smooth when mature, short petioled, lanceolate, of varying bluntness, serrate, feather-veined, the veins not reaching the margins, and from five to ten, or in the much larger wild plant, from fifteen to twenty centimetres long (Fig. 5083).

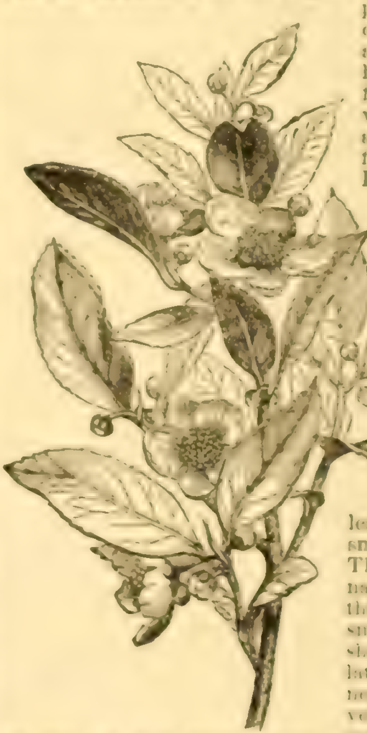

FIG. 5083.—Tea plant. Flowering Branch. (Baillon.)

Flowers axillary, one, two, or three together, on short recurved peduncles, about the size and shape of cherry blossoms, creamy white. Sepals five, petals five or more, cohering at the base. Stamens numerous, filaments cohering at the base, and also slightly attached to the bases of the petals. Ovary superior, three-celled, with several ovules in each cell (Figs. 5084 and 5085). Fruit, a slow-ripening, fleshy capsule, finally loculicidal, three-celled, with two or three oily, albuminous seeds in each cell.

Tea is a native of Asia, and grows in a semi-wild state in many of the districts where it is cultivated, but has only been found in an unquestionably indigenous condition in Assam, where it was discovered some fifty years ago by Mr. Robert Bruce, as a good sized tree, with very large leaves. It is now cultivated in many parts of the world; first in importance in China, where it is said to have been domesticated more than a thousand years ago, also in great quantity in Japan, Java, and India, to a slight extent in South America and elsewhere, and finally in the United States, experimentally. Although it grows pretty well in many places, and is comparatively hardy, the higher price of labor is a bar to its profitable production in most civilized countries.

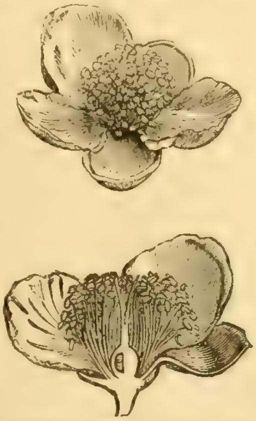
FIG. 5084.—Flowers of Tea-plant, with Section. (Baillon.)

The earliest knowledge of the use of Tea is from the Chinese, to whom it was familiar one thousand and perhaps two thousand years ago. It was introduced into Japan in the thirteenth century, A. D., and into Java and India in recent times. It was first used in Europe near the middle of the seventeenth century.

Tea is planted in gardens and tended without gathering until two or three years old, then the leaves and buds are plucked for two or three successive crops each season. If green tea is to be made, they are immediately dried over a heated stove, and afterward colored more or less. For black tea the leaves are pressed in little heaps, and allowed to wilt and ferment a little before drying, which is effected in the same way as above; by this process some of the tannin is decomposed, and the essential oil altered so as to modify the taste and smell a little; its color is also very much darkened, as well as that of the infusion made from it. The principal varieties of tea are: Black—flowery pekoe, orange pekoe, souchong, congou, bohea, etc. Green—gunpowder, imperial, hyson, young hyson, etc. The Teas of our market are nearly always "blends," made by mixing several grades together.

The usual shape of Tea is attained by compressing and rolling the leaves in the hand, or upon a table until they are crumpled into the little rolls or wads of which commercial tea consists; in the nicer sorts each leaf is rolled by itself.

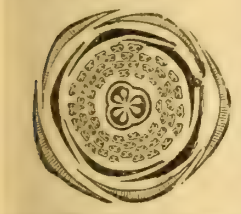
FIG. 5085.—Plan of Flower. (Baillon.)

COMPOSITION.—In the proportions of the ingredients there is considerable variation, but the following are the principal ones: *Essential Oil* from one-half to one per cent., which is the source of its flavor; *Caffeine* (Theine) from one-half to two or three per cent., which gives it bitterness. This alkaloid is found in half a dozen other plants, most of which are used somewhere as stimulating food adjuncts (see Caffeine, Guarana, Cola Nuts, etc.). It is also related to Cocaine and Theobroma. The amount of *tannin* in tea is large (from twelve to seventeen per cent.).

ACTION AND USE.—The large amount of tannin found in Tea makes it an active astringent, especially to those unaccustomed to its use. It constipates the bowels, impairs the digestion, and reduces intestinal secretion when taken in large quantity; locally it makes tea a mild hæmostatic, and a useful wash for indolent ulcers, exuberant granulation, etc. The essential oil gives to Tea its agreeable flavor, and a good part of its exhilarating character; it relieves fatigue, stimulates thought, postpones sleepiness, and cheers the mind. The *caffeine* is also a mental and nervous stimulant and cardiac tonic of considerable importance. By long-continued, habitual use neither of the above effects is much felt, unless carried to the extent of diminishing the appetite and developing dyspeptic troubles.

The least desirable of the constituents of Tea is the *tannin*, it is also one of the slowest to dissolve out, and can, therefore, with a little care, be largely left with the dregs. The quicker an infusion of Tea is made the more fragrance and less bitterness and astringency it has, and the more slowly, the more tannin. Tea for drinking should be made by pouring *boiling* water into a suitable vessel containing the tea and allowing it to stand from five to ten minutes, no longer. A better way is to rinse the cup in boiling or very hot water until it is heated through, then put in a teaspoonful of dry tea, fill the cup with boiling water and allow to stand a few minutes. Tea should never be boiled, or stand long unless the *tannin* is wanted. If made in an iron vessel or in a tin one which has begun to wear, it will become dark from the formation of a bitter tannate of iron. On account of its almost universal use over the entire world, Tea is not often available as a medicine; its effects are identical with those of coffee, but perhaps more astringent and less stimulating than that article. As is the case with coffee, the commercial value of Tea depends more upon its aroma than on the amount of caffeine it contains.

ALLIED PLANTS.—There are a dozen or more species of *Thea*, one of which is *Thea Japonica*, the beautiful Camellia of the gardens. Besides this there is nothing of economic importance in the order.

ALLIED DRUGS.—Caffeine, Coffee, Theobroma, Guarana, Coca, etc. *W. P. Bolles.*

TERMINOLOGY, ANATOMICAL. § 1. DIVISION OF THE SUBJECT.—Current anatomical terms are fairly represented in the following selections, from Huxley's "Vertebrated Animals" (1873*), and from a paper by the same author (1881):

A. "The red corpuscles of mammalia are usually circular."

B. "The clavicles of the dog are always rudimentary, and are generally represented by a gristly intersection of muscles."

C. "In a human fœtus the manus and pes are very similar in size and form."

D. "Speaking broadly, the back of the arm corresponds with the front of the leg."

E. "In the latter part of the period of gestation the legs gain on the arms, and the proximal segments of the limbs on the distal ones."

F. "The cornua come to lie somewhat dorsad of them."

§ 2. The terms included in the foregoing sentences may be grouped primarily as follows:

I. Such as designate parts; *e.g.*, *arms*, *manus*, *cornua*, *clavicles*.

II. Such as indicate the attributes or relations of parts; *e.g.*, *circular*, *red*, *similar*, *represented*, *corresponds*, *proximal*, *dorsad*.

Among the terms in group II., those referring to size and color need not be specially considered. Those that indicate relations of similarity or identity are enumerated in § 81. The terms which express form, location, and direction are discussed under Toponymy † (p. 533). The terms embraced in group I. are the names of parts, organ-names or *organonyms*, and their consideration constitutes *organonymy*.‡

§ 3. Historical Note.—Aside from dictionaries of realized and adequate terms which naturally and prudently (although not, as elsewhere intimated by the writer,* with the highest possible effect upon glossary) are confined to a somewhat indiscriminate presentation of existing terms, useful treatises upon anatomical terminology date back little more than a century (Vicq d'Azyr, 1786), and those writers who have given serious and extended attention to the subject are far from numerous. Among these, Whewell (1840) discusses mainly general principles, and Barclay (1803), while presenting the whole subject, elaborates especially a set of topographic (descriptive) terms. The two most helpful papers upon nomenclature proper are Owen's immortal "Report" (1846), and Pye-Smith's "Suggestions" (1877). After a recent reperusal of these two papers, the writer regrets that space will not permit even more extended extracts than are given in the following pages (§ 43, Appendixes XXVII., XXXII., etc.). He cannot refrain from expressing the opinion that no one is fully qualified to deal with the general subject of Anatomical Terminology without an acquaintance with the views of the four writers last named. Others who have contributed to the subject, directly or indirectly, are named in the Bibliography or quoted among the aphorisms, § 43.

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* See list of publications at the close of this article.

† This division is by S. H. Gage, the remainder by B. G. Wilder; their views upon both divisions of the subject are, however, nearly identical, as may be seen from their joint publication, "Anatomical Technology" (especially the Introduction, and the Preface to the second edition).

In this connection acknowledgment may be made of valuable assistance upon linguistic matters rendered the writers by their colleagues, past and present, T. F. Crane, Isaac Flagg, W. G. Hale, W. T. Hewett, Tracy Peck, and B. I. Wheeler; the last-named especially has kindly answered a very large number of queries.

‡ These terms are from the Greek ὄνυμα (a name), and the words for part (ὄργανον) and position (τόπος). In the writer's earlier papers, and in the first edition of "Anatomical Technology," the words were spelled *organonomy* and *toponomy*, as if from ὄνομα, the other form of ὄνυμα. The change is made for the sake of uniformity with *synonym*, etc., and in accordance with the considerations offered by Coues (1884). The adjective should be *onymic*, as in *patronymic*, rather than *onymal*, used, perhaps without reflection, by Coues and J. A. Allen.

ORGANONYMY.

§ 4. Most of the kinds of organonyms (names of organs or parts) in common use are represented in the following passages, mainly selected from the account of the development of the brain in Huxley's "Vertebrated Animals," 1871.† The words in brackets are taken from the writings of well-known anatomists for the sake of including more varieties of terms. These names constitute good illustrations of existing nomenclature, and any criticism to which they are justly subject would apply with greater force to the less well chosen terms in the less perfectly constructed writings of less eminent anatomists.

Here and elsewhere in this division of the article, encephalic terms will be commonly selected, partly because of the writer's greater familiarity with them, and partly because, as remarked by Pye-Smith, "the nomenclature of the brain needs revision more than that of any other part."

§ 5. A. "The hind-brain is differentiated into the medulla oblongata behind, and the cerebellum with the pons Varolii (Lat., also pons;‡ Eng., pons or bridge; Ger., [illegible] or Brücke; Fr., pont; It., ponte; Sp., puente), in front."

B. "The components of the mid-brain or mesencephalon are the optic lobes (corpora bigemina or quadrigemina), the crura cerebri, and the interposed cavity which is reduced to a mere canal, the [aqueductus Sylvii or] iter a tertio ad quartum ventriculum [passage from the third to the fourth ventricle]."

C. "The sides of the anterior vesicle thicken greatly and become the optic thalami, which are connected by a gray, soft commissure; transverse fibres developed in the lamina terminalis [§ cinerea] constitute the anterior commissure."

D. "A few fan-shaped gyri are developed upon the insula."

E. "The pia mater dips into these sulci."

F. "The ventral face of the metencephalon presents on each side a flattened rectangular area, the corpus trapezoides [or trapezium]."

G. "The calcarine sulcus ("posthippocampal fissure" of Owen) causes a projection into the floor of the posterior cornu which is the hippocampus minor [later called by Huxley, calcar]."

H. "There is, in man, no diastema, though the summits of the canines project slightly beyond the level of the other teeth."

I. The paragraph (Huxley's "Vertebrated Animals," p. 60) respecting the spinal portion of the central nervous system is headed "myelon," but this word, so far as the writer is aware, does not occur elsewhere in the volume; "spinal cord" is commonly used, but "cord" alone in the paragraph indicated.

J. The cerebral surface becomes "complicated by ridges and furrows, the gyri and sulci." The first to be recognized is the "Sylvian fissure," and the second the "fissure of Rolando," the latter being called (see explanation of Fig. 21) "sulcus of Rolando."

§ 6. Groups of Organonyms.—Names of parts may be grouped in several different ways, viz., as to parts of speech (§ 7), syllabication (§ 8), derivation (§ 9), form (§ 40), authority (§ 19), degree of comprehensiveness (§ 21), nature of the attribute implied (§ 12), personal sense which they convey (§ 16), constancy and consistency (§ 16), euphoniousness (§ 20), etymological accuracy (§ 66), reference to individuals (§ 18), number of component words (§ 24), kind and degree of equivalency to other terms (§ 32).

§ 7. Parts of Speech.—Anatomical terms consist for the most part of substantives or adjectives, although some polyonyms comprise also prepositions (as in iter a tertio, etc.), and certain obsolete phrases contain pronouns, adverbs, verbs, and conjunctions so as in fact to constitute nearly complete sentences, e.g., fissura medullaris, qui intercedit inter thalamum et corpus striatum (Burdach, 1822).

§ 8. Number of Syllables.—Anatomical names may consist of a single syllable (e.g., pons), of two (e.g., [illegible]), of three (e.g., cerebrum), of four (e.g., cerebellum), or of five (e.g., infundibulum). Words of four or more syllables are polysyllabic; those of less than four (trisyllables, dissyllables, and monosyllables) are oligosyllabic.

Monosyllables are apt to be abrupt and undignified, while anything beyond a quinquesyllable is difficult to pronounce or even to grasp at sight as a single word. In fact, with any series of six or more objects, even if separated by distinct intervals, the exact number is not commonly recognized at a glance as with five or less.

§ 9. Diminutives.—Cerebellum (a small brain) is the regular diminutive of cerebrum, the brain; but, like most other diminutives, the word itself is longer than the original; this is the case with pes (a foot) and pedunculus (a little foot), and with falx (a sickle) and falcicula (a small sickle)—the latter, by the way, being employed in the article Gross Anatomy of the Brain as a mononym for falx cerebelli. The inverse ratio between the size of the objects and the length of the names which characterizes diminutives, is in harmony with the general rule that words or phrases designating a part are longer than those which represent the whole, e.g., arm, upper arm, forearm; America, North America, South America.

§ 10. Metaphorical Names.—In designating parts of the brain, e.g., pons and insula, the names are transferred from the original object to something that has, or is supposed to have, some resemblance thereto; this transfer constitutes a metaphor, as when we call a man a "fox" or a "lion"; the comparison is implied. Other metaphorical encephalic names are aqueduct, thalamus, hippocampus, [illegible], etc.

§ 11. But with some names the comparison is directly expressed, commonly by a dionym consisting of a common noun (corpus, pars, lamina, etc.), with an adjective ending in the Latin formis or the Greek oides, denoting likeness. Such a term is corpus trapezoides, signifying a body resembling a trapezium. The conversion of the polyonym, simile name, into one which is mononymic and metaphorical may commonly be effected, as it has been in the example above given, by omitting the common noun and reducing the adjective to the substantive from which it was derived.

§ 12. Attributive Names.—Most organonyms refer, at least in part, to some real or fancied attribute, as, e.g., size (hippocampus major), consistence (corpus callosum,

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* [illegible] of the paper "[illegible]," [illegible] American [illegible], New York Medical Journal, [illegible]

† [illegible]

‡ [illegible] pons, etc.

§ [illegible]

soft commissure) ; color (*substantia nigra*) ; shape (*hemisphere, medulla oblongata*) ; function (*aqueduct of Sylvius*) ; course (*vagus*) ; distribution (*pneumogastric*) ; location (see § 13).

§ 13. Locative Names.—Names indicative of position are very common—*e.g., anterior vesicle ; mesencephalon ; lamina terminalis ; ectoglutæus* and *paracentral lobule.* Locative names form two groups : (*a*) Such as indicate the position of a part relative to another part, larger, more important, or earlier designated, with which it has merely a general association in other respects ; *e.g., paracentral lobule* indicates the topographical relation of a mesal area of the cerebrocortex to a fissure on the other (lateral) aspect of the hemicerebrum ; *lamina terminalis* and *filum terminale* indicate the locations of the parts in question at the extremities of the entire neuraxis ; *adrenal* signifies the neighborhood of the body formerly called *supra-renal capsule* to the kidney (*ren*) ; *precuneus* indicates that the cortical area lies cephalad of the cuneus. (*b*) Such as indicate the relative positions of parts constituting a natural or conventional series ; for example, *anterior vesicle* implies the existence of a posterior ; *posterior commissure* implies the existence of an anterior ; *mesencephalon* (middle brain) would have no appropriateness unless there were two extremes of a series. The advantages of locative names will be presented farther on (§ 54).

§ 14. Order.—*Seventh cervical vertebra, first rib; last costal cartilage,* and *fifth cranial nerve* imply the existence of a series of comparable parts. Such names might be called *ordinal,* but they are practically only a variety of locative names, since the general consent of anatomists has established the rule that, of two or more parts forming a cephalo-caudal series, that nearest the head is to be taken as first. This is applied likewise to the fingers and toes, which, in the normal position of the arms and legs, form a cephalo-caudal series, the thumb (pollex) and the great toe (hallux) being reckoned as first in the hand and the foot ; on this group of names, see also the toponymic division of this article, § 94.

§ 15. Correlation.—The adjective *calcarine* (as applied to a sulcus [fissure]) is evidently derived from the noun, *calcar,* and the stated collocation of the ectal depression with the ental elevation is implied in the correlation of the two terms. Similar instances are *hippocampal* from *hippocampus.*

§ 16. Consistency.—As appears in § 5, I., the same part is designated in different passages as *cord, spinal cord,* and *myelon,* with no direct intimation that the three terms are equivalents. In J., it is implied that all cerebral depressions are *sulci,* but the first two named are called *fissures,* and one of these again is called *sulcus.* Within fifty pages of a standard neurological treatise, in addition to the Latin *crus fornicis,* there occur the following vernacular equivalents : *Fornixschenkel ; Gewölbschenkel ; Fornixsaülchen.* Terminological variety, such as occurs in the passages quoted, may be expressed by the single word, *pœcilonymy* ;* § 72.

§ 17. Indirect Pœcilonymy.—The examples given above are of what may be called *direct pœcilonymy ; i.e.,* two or more substantives are applied to the same part ; but perhaps even more frequent is indirect pœcilonymy, or pœcilonymy by implication, where one substantive is applied to the part itself, but to the same or a related object is applied either a name or an adjective derived from another and totally different word. In the translation of a well-known article the great cerebral commissure is called, as usual, *corpus callosum,* but in one passage occurs the adjective "*trabecular*" (=callosal) ; *trabal* (Latin, *trabalis*) would merely recall the obsolete name for the callosum, *trabs cerebri ;* but *trabecular* implies *trabecula,* the diminutive of *trabs.* The former case would be simple, the latter is *compound, indirect pœcilonymy.*

§ 18. Reference to Individuals.—*Pons Varolii* and *aquæductus Sylvii* imply some relation between the parts so named and the anatomists, Varolius and Sylvius ; such terms, derived from the names of persons, are called *eponyms ;* there are many of them in anatomy, and their merits will be considered later ; § 59.

§ 19. Authority.—This may depend upon one or more of three distinct factors, viz., (*a*) antiquity ; (*b*) general use ; (*c*) employment by one or more eminent anatomists. *Cerebrum* and *cerebellum* are strictly ancient terms. *Spinal cord* is in almost universal use among the laity and anatomists alike. Robin's suggestion of *neuraxis* (in the Galloparonym, *neuraxe*) entitles it to consideration (see the article, Gross Anatomy of the Brain, § 6) ; while *myelon* (also, in fact, an ancient term), proposed by Owen and adopted by Huxley, requires but few influential adherents to supersede *spinal cord* entirely. How far priority and authority may justly be disregarded, will be considered later ; § 44.

§ 20. Explicitness.—The verbal representations of objects differ widely in this respect, *i.e.,* as to their completeness. For example, the brain might be represented either (1) by a full description of all its parts ; or (2) by the statement that it is the intra-cranial portion of the neuraxis ; or (3) in place of *brain,* might be used *encephalon* (ἐν, in, and κεφαλή, head), referring to its location ; or (4) any other word in any language might be substituted, provided the substitution were announced ; or (5) any abbreviation might be employed ; or (6) a wholly artificial and conventional sign or number might serve as the written or spoken symbol of the complex organ. These grades of representation are contrasted in the following table :

Tabular arrangement of the grades of verbal representation of organs :

A.—Descriptions.
    a. Complete, or approximately so.
    b. Partial, constituting a definition or characterization.
B.—Designations.
    a. Natural or indicative.
    b. Artificial or arbitrary.
        α. Names or abbreviations.
        β. Symbols ; signs or numbers.

From the above table it will be seen that the primary distinction is between names that are *descriptive* and those that are *designatory ;* between those that make, as it were, an attempt to offer an account of the parts, and those that are content with pointing out some general feature without entering into details. *Pons, fornix,* and *encephalon* are good examples of designatory terms, while a typical descriptive term is the following, from Burdach : *Corpus pyramidale striatum inferius, externum, posticum.*

§ 21. Idionyms.—Among organonyms some are restricted in their application to particular organs ; *e.g., cerebellum, lamina terminalis ;* these are comparable to what are called proper names, and may be termed *idionyms* (Gr., ἴδιος and ὄνυμα). Other organonyms, like common names, may refer to any one of many parts ; *e.g., canal, sinus, cavity, side, roof, floor, segment ;* others, again, are intermediate in comprehensiveness, and are applied often to either of several similar parts constituting a series ; *e.g., muscle, nerve, artery. Ventricle* designates only certain cavities (of the heart, brain, and larynx) ; *commissure* is nearly confined to the neuraxis ; *cœle* is used by some for the encephalic cavities (§ 80). Owen's names for the elements of a typical vertebra, *centrum, neurapophysis, hæmapophysis,* etc., are examples of this group of idionyms.

Certain classical terms that had originally a more or less general application, have come to be restricted to special parts. For example, with both the Greeks and Romans, διάστημα, *diastema,* signified any kind of interval, more particularly in music ; this latter meaning seems to be retained for the English form (Angloparonym), *diastem ;* but in anatomy, *diastema* refers specifically to an interruption of the dental series in either jaw for the intrusion of the crown of the canine belonging to the opposed jaw. In this restricted, idionymic, sense it is used without definition by Huxley (see above, § 5, H.).

§ 22. Homonyms.—In anatomy there are words which, identical in pronunciation or spelling, or both, are applied to two or more dissimilar objects. *Os*, a bone, and *os*, the mouth, are familiar homonyms. In most of these cases there is really no more probability of misapprehension than when the word *radius* is used in its mathematical or anatomical sense; or, when Huxley applies the phrase *mental prominence*—which certainly *might* signify intellectual superiority—to a bony projection corresponding to the chin.

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* From ποικίλος, various, changeful, inconstant ; cf., ποικιλόβουλος, of changeful counsel ; *pœcilopoda*—various footed. The unfamiliar term is perhaps the less objectionable, in that it stands for a habit which may ere long be eradicated.

§ 23. Polychrestic Words.—The same word may do duty in many different connections, either by application, unchanged, to members of more or less extensive classes of parts, or by composition, becoming portions of distinct names. Such words, useful in so many ways, may be called *polychrestic*, although this adjective is commonly applied to drugs of various utility. A good example is *occipital*. This adjective distinguishes from the others of the same general group, an artery, a bone, a crest, a fissure, a fossa, a groove, a lobe, a protuberance, a region, a sinus, a triangle, and a vein; united with the prefixes *ad*, *basi*, *ex*, *mid*, *par*, *pre*, *prepar*, *postpar*, *sub*, and *super*, it serves to designate as many parts, fissures, gyres, and bones. Compounded with *atlad*, *axiad*, *frontal*, and *parietal*, it is applied to joints, a muscle, and a fissure. A certain fissure is commonly known as the "transverse occipital." Deducting one (since one fissure is designated by *occipital* and *occipito-parietal*), there remain twenty-six parts which the single word *occipital* aids to designate. In greater or less degree, polychresty is predicable of many other words, *e.g.*, *frontal*, *dorsal*, etc.

§ 24. Mononyms and Polyonyms.—In the writer's opinion the most radical and far-reaching of all distinctions between anatomical terms is this: Some consist of but one word each; others of two or more; the former are *mononyms*, the latter, *polyonyms*.*

§ 25. There are two methods of securing mononyms from pre-existing polyonyms. A. By the omission of unessential words. The omitted word or words may be special and particular, as, *e.g.*, when *Societas de Propaganda Fide* is reduced to *Propaganda*, which is used as a collective noun like *army* or *convention*; or they may be common and general, as when *filtrate*, *precipitate*, *distillate*, etc., are used without the understood *substance*, *material*, *part*, or *portion*. Among encephalic terms, the reduction of *aqueduct of Sylvius* to *aqueduct*, of *corpus callosum* to *callosum*, of *foramen* [illegible] to *foramen*, are examples.

B. By the compounding of two or more of the separate words, *e.g.*, *postfrontalis* from *frontalis posterior*; *supraoccipitalis* from *occipitalis superior*; *postpeduncularis* from *pedunculus posterior*.†

§ 26. Mononyms by Association or Implication.—With series of parts having the same general constitution, *e.g.*, the vertebræ, ribs, muscles, nerves, arteries, veins, metacarpal and metatarsal bones, and the cerebral fissures and gyres, it would be wellnigh impossible to apply to each a distinctive mononym like *atlas*, *axis*, [illegible], and a few others; hence the entire designation is at least a dionym, consisting of the common noun (*vertebra*, *nervus*, *fissura*, etc.) with a more or less distinctive adjective ([illegible], [illegible], *ventralis*, etc.). In nearly all cases, however, the context so far indicates the group of parts that the common name may be omitted, and the adjective may be employed alone without ambiguity. When there is but a single adjective the term, although theoretically a dionym, becomes practically a mononym. In a few cases the adjective is applied to no other part, and is therefore distinctive or idionymic, *e.g.*, *phrenicus*.

The substantive *cord* is an example both of polychresty (§ 23) and of mononymy by implication. Combined with appropriate adjectives it designates at least five organs of entirely distinct structure; but in many cases the context warrants dispensing with the adjective, and the "cords" of the laryngologist, the neurologist, the obstetrician, the surgeon, and the embryologist may thus refer to the vocal bands, the myelon (spinal cord), the funis (umbilical cord), the spermatic cord, and the notochord (dorsal cord) with little risk of misapprehension.

§ 27. Reducing Polyonymic Qualifiers to Mononyms.—Usually these may be treated as if they were partly substantive and partly adjective, and reduced according to the methods named in § 25. For example, for *glutæus major*, *medius*, and *minor*, Owen has proposed *ectoglutæus*, *meso-* and *entoglutæus*; for *external* and *internal carotid*, *ecto-* and *entocarotid*; for *vena cava anterior* and *posterior*, *precava* and *postcava*; all of the same author's fissural and gyral names are mononymic adjectives (1868, pp. 136, 137). With these precedents the writer proposed, in 1873, *ectopectoral* and *entopectoral*; in 1882 ("Anatomical Technology," p. 207), *latissimus*, *coracodeus*, *indicator*, etc.; in 1884, a series of mononymic simplifications of the common names of the larger encephalic arteries (*e.g.*, *medicerebral* for *middle cerebral*, etc.);* the fissural and gyral names employed in the article, Gross Anatomy of the Brain, are substantially those which were proposed by the writer in 1884, modelled largely after those of Owen.

§ 28. Source.—Most of the words in § 5 are classical in origin, *i.e.*, derived from the Latin or Greek; *e.g.*, *pons*, *cerebrum*, *hemisphere*, *hippocampus*. Others are vernacular, *i.e.*, English (used in the most comprehensive sense as equivalent to non-classical), *e.g.*, *brain*, [illegible], and *sides*. Vernacles or vernacular terms would include also words of German origin, and such French and Italian words as have no immediate Latin or Greek antecedents.

§ 29. In this connection, notice may be taken of the fact that a large number of apparently Latin words do not occur in ancient Latin writings, or in lexicons based thereon. For example, while *quadrigeminus* (four-fold) is true Latin, *bigeminus* is a modern combination perfectly legitimate and acceptable. There are also words from various modern, and even barbarous, languages which have been Latinized, and some of these (*e.g.*, [illegible]), have all the appearance of genuine Latin words.

§ 30. Form.—Irrespective of their source, certain terms are obviously English, *i.e.*, they are Angliform, *e.g.*, *forebrain*, and *posterior cerebral vesicle*; others are Latiniform, *i.e.*, *crura cerebri*, and [illegible]; these latter are recognized as Latin because of the regular forms of cases, the genitive (*cerebri*), ablative ([illegible]), and accusative ([illegible]), which do not (as yet) occur in English. With other terms the presumption is that they are English (*e.g.*, *posterior cornu*), or Latin (*corpora bigemina*), because the adjective precedes the substantive in the former case, but follows it in the latter. But the general rule as to the relative position of the substantive and adjective has many exceptions, *e.g.*, *Hotel Brunswick*, and *notary public*, in English, and *pia mater*, *alma mater*, etc., in Latin.†

§ 31. Besides the words above mentioned, which are recognizable as Latin or English from their spelling or their relative position in polyonyms, there are some which are either Latin or English according to circumstances; *i.e.*, the question of their Latinity is determined by their environment. *Cerebellum*, for example, is a Latin word; but it is also English by adoption; it occurs in English lexicons, is used in ordinary speech, is pronounced as any English word would be, and is not usually italicized; the same may be said of *medulla*, taken alone, and even of *thalami*, although the form of the Latin plural is retained (instead of the regularly English *thalamuses*), and although in the dionym, *thalami optici*, it is unquestionably a Latin word.

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* [illegible]

† [illegible]

* These are adopted in the article Vessels of the Brain.

† In the opinion of Professor B. I. Wheeler, the relative position of the substantive and adjective [illegible]

§ 32. Equivalency.—Among the terms at the end of § 5, A, all refer to the same part of the brain and are therefore equivalent terms. But, if *pons Varolii* be taken as the basis, they differ in this respect, *viz.*, most of them are in another language than the Latin, while *pons* is in that language; strictly speaking, *pons* and *pons Varolii* are *synonyms*, while *bridge*, *Brücke*, *pont*, *ponte*, and *puente* are not, but may be called *isonyms*, from the Greek **ἴσος**, equal. In like manner *trapezium* and *corpus trapezoides* are Latin synonyms.

§ 33. Paronyms and Heteronyms.—Among the equivalents of *pons Varolii* other than the Latin synonym *pons*, it will be noted that the French *pont*, the Italian *ponte*, and the Spanish *puente* are derived from *pons*, directly or indirectly; while the German *Brücke* and the English *bridge* have no such Latin antecedent. The former are *cognate* with the Latin, the latter are not. The former are *paronyms* of the Latin *pons;* the latter are *heteronyms* or vernacular translations. In general terms the relation between the Latin *pons* and the French *pont* is one of *paronymy;* but between *pons* and the English *bridge* it is one of *heteronymy*.

Other familiar illustrations are the following:

Canal is derived from the Latin *canalis*, constituting in fact the stem of that word without its case-endings. The difference between the two is merely that the one is English and the other Latin; *canal* is *canalis* Anglicized; it is its paronym. But *tube, passage, trough, water-course*, and *aqueduct*, while they may *mean* the same as *canalis*, are totally different words; they have no etymological relationship, direct or indirect; they are *heteronyms*.

Vesicle is a paronym of the Latin *vesicula; lobe* is a paronym of *lobus*, but *mid-brain* is a heteronym of *mesencephalon. Sylvian aqueduct* and *aqueduct of Sylvius* are both paronyms of *aquæductus Sylvii; ventricle* is a paronym of the Latin *ventriculus*, but the phrase "passage from the third to the fourth ventricle," is a heteronym of the Latin polyonym, *iter e tertio ad quartum ventriculum*.

§ 34. Paronymy and heteronymy among words are comparable with the relations of homology and analogy among organs. An organ which is the same as another in essential structure, is its homologue; but its analogue when it merely subserves the same function; see § 81.

§ 35. So far, there have been mentioned only Latin words and their English equivalents; but there are paronyms and heteronyms in all languages. For example, the Greek **ἀταξία** means disorder or irregularity, and these two English words are its heteronyms. But the word itself occurs in all modern languages with such slight modifications as adapt it to what is called the "genius" or "spirit" of each tongue. The complete series is as follows: Greek, **ἀταξία**; Latin, *ataxia;* English, *ataxy* (or *ataxia*)*;* Spanish, *ataxia;* Italian, *atassia;* French, *ataxie;* German, *ataxie*. Each of these is a geographical variety, so to speak, of the original; it is as if one and the same individual were simultaneously an inhabitant of seven different lands, and in each adopted the distinctive costume of the people.

§ 36. Paronymization.—The application of the principle of paronymy in a given case is *paronymization*, or the word is said to be *paronymized*. The several forms of the process are indicated in the following table:

Table of the names of special forms of paronymization.

To convert into English is to Anglicize.
" " " French " " Gallicize.
" " " German " " Germanize.
" " " Italian " " Italianize.
" " " Latin " " Latinize.
" " " Greek " " Hellenize.

Proper names offer familiar examples of paronymy. The English, *John, Charles*, and *William;* the German, *Johann, Karl*, and *Wilhelm*, and the Latin, *Johannes, Carolus*, and *Guilielmus*, are all paronyms of one another.

Paronyms, then, are like naturalized foreigners; they are words that have been adopted into another than their original tongue; and the process of paronymization (including the several specific forms, Latinization, Anglicization, etc.), may be defined as word-adoption, word-appropriation, word-assumption, or word-borrowing.

§ 37. Although the term *paronymy* was published only a few years ago (in the writer's paper (1885 *), and in "Anatomical Technology" (1886), preface to second edition), the process of paronymization dates back to the time of the first conversion of a Greek word into a Latin,† and there are more or less distinct recognitions and even designations of it in various writings. In Webster's dictionary the words in brackets are commonly paronyms, while the definitions are more often heteronyms. In the preface to his translation of the "Iliad," William Cullen Bryant remarks, "The names have become naturalized in our language for centuries, and some of them, as Mercury, Vulcan, and Diana, have even been provided with English terminations." Haldeman notes (1843, 20) that "the similarity of some words is so great in different languages, that they look like old acquaintances, upon seeing them for the first time." A recent writer (Hutchinson, New York *Medical Record*, October 25, 1885, 471) declares that "Latin names should be reduced to English," although neither he nor, so far as the writer is aware, any other has described or designated the process by which the reduction is to be accomplished.

§ 38. Holoparonymy and Meroparonymy.—When a Latin or Greek word has been adopted or naturalized into all modern languages, then it is an example of holoparonymy (Gr. **ὅλος**, complete). Such is the series from the Greek **ὄργανον**; Latin, *organum;* English, *organ;* French, *organe;* Italian, *organo;* German, *organ. Ataxia* has been mentioned (§ 35); others are *anatomy*, and *mulus*. Some lack but one of the series; *e.g., agonia, fibra, stella;* but these, with the host of cases (easily found in any large English dictionary) in which two or more possible forms are wanting, may be accepted as illustrations of partial paronymy or meroparonymy (Gr. **μέρος**, partial).

§ 39. Paronyms other than Nouns.—Literally, of course, only *names* (substantives) can be paronyms, but the multiplication of terms may be avoided by applying the word and its derivatives to other parts of speech. The Latin adjective, *vitalis*, for example, becomes *vitale* in Italian, but *vital* in English and French; the German would probably be *vitalisch*. The English *organic*, and the French *organique*, are paronyms of the Latin *organicus*. The English verb *move* is paronymized from the Latin *moveo*, and the adverb *nobly* from *nobiliter*.

§ 40. Paronymic Dimorphism.—In some cases more than a single form has been adopted in a given language. Sometimes both of these refer to the same part, *e.g., pedunculus* and *peduncle;* sometimes to distinct parts, *e.g., ligula*, and *lingula*, both primarily diminutives of *lingua*. Besides *canal, channel* and *kennel* are paronyms of *canalis*.

§ 41. Anaparonyms.—In a few cases, a word which had already been adopted from one language into another has been readopted into its original source, with a second change of form; *e.g.*, the English *beef* is a paronym of the French *bœuf*, and this in its turn has been anaparonymized in French restaurants as *bif*. For the word, *anaparonymized*, warranting *anaparonym, anaparonymy*, and *anaparonymization*, the writer is indebted to his colleague, Professor B. I. Wheeler, who cited **ἀναβαπτίζω**—rebaptize; other words in which *ana* has the

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* Paronymy versus Heteronymy, etc., Jour. of Nervous and Mental Disease, July, 1885.

† As compactly described by Campbell: "When a convenient Latin word was wanting, in making their translations, the Romans never stopped to coin one of their own, but took the Greek word and dressed it in Roman type and terminations."

[illegible] [illegible] are [illegible]; [illegible] [illegible] or [illegible].

§ 42. Unrealized Words.—These are words that have not as yet come into actual use, but are, so to speak, only potential. Every noun suggests the possibility of a corresponding derivative adjective; so, likewise, does every adjective imply the existence, actual or potential, of the noun from which it has been or might have been derived. In some cases, however, an adjective may be in actual use before the corresponding noun has been employed; e.g., *basicranial* obviously justifies *basicranium*, or even *basicrania*; but so far as known to the writer, neither of these has been actually used, *base of the skull* or *basis cranii* having been found sufficient. There is no separate Latin word *cele*, but the Latin compound *hydrocele* shows that such a term might have been used had there been need of it; at present it is the latinized paronym of the Greek κήλη. *Onym* (§ 2, *note*) occurs much more frequently in derivatives than by itself. Other examples are [illegible], [illegible], and [illegible] (the supposed adjective from which [illegible] is derived). The case is analogous to that of the assumed chemical element, *fluorine*, now known only in its compounds. The writer's *enteron*, for the entire alimentary canal (see p. 110, § 8), is warranted by the common adjective *enteric*, as well as by the compounds, *mesenteron*, etc.

§ 43. Aphorisms Respecting Nomenclature.—Under this head are collated extracts from various authors, with occasional contributions from the writer. Many of the paragraphs are not strictly aphoristic in length or in other respects, but they constitute, upon the whole, a compact summary of the history and principles of the subject, and may at least serve to show that the writer's views are in close accord with the general tendency of terminological modification; indeed, that so far from proposing numerous and radical innovations, he has confined himself mainly to crystallizing and formulating those already published, and has simply been somewhat more persistent and consistent than others in their advocacy and application.

Aph. I. "The first requisite for the accurate discussion of any subject is an appropriate nomenclature." (A. Agassiz.)

Aph. II. "Every calling has its technical terminology, and every artisan uses terms of art which sound like gibberish to those who know nothing of the art, but are exceedingly convenient to those who practise it." (Huxley.)

Aph. III. "The best workman uses the best tools. Terms are the tools of the teacher; and only an inferior hand persists in toiling with a clumsy instrument when a better one lies within reach." (Owen.)

Aph. IV. "While the name of any article is one of its most trivial and artificial attributes, laxity in the use of nomenclature causes endless perplexities and hindrances in the progress of knowledge." (Flower.)

Aph. V. "Half the difficulty of anatomy is inherent; the other half is in wordiness. The trouble with the student is more in the names of things than in the things themselves. He mistakes one for the other, his head swims, and then he founders in a Latin storm at sea." ([illegible].)

Aph. VI. "It is well known to all how much terminological appliances have accelerated and facilitated science." (Gill.)

Aph. VII. At the present time it is the fashion to extol the importance of improved methods, of mechanical devices by means of which facts are ascertained and verified; but if these same facts are to be intelligently and profitably described and discussed, surely whatever facilitates verbal and mental operations is not without value.

Aph. VIII. "Much confusion has been occasioned by importing into comparative anatomy [descriptive] terms employed in human anatomy; but the efforts of Owen, Huxley, and others to introduce terms of general applicability to vertebrate animals have resulted in a great improvement of anatomical nomenclature." (R. Ramsay Wright.)

Aph. IX. It is certainly possible to overrate the importance of nomenclature, just as one may spend too much time upon chirography, to the neglect of the subjects written upon; but those who take [illegible] stand upon the epigram "to need a new terminology is a sign of mental poverty," are in danger of [illegible] some anatomical writers; they may carry their laxness so far as to use several terms for the same object, to employ English, French or German indifferently, and even to introduce new words without apology or explanation; their affectation may be compared with the indifference to legibility in writing exhibited by eminent writers and cultivated by modern would-be geniuses.

Aph. X. "Stereotyped formulas are repeated by each succeeding generation of the unthinking multitude, in whose mouth the inheritance receives no increment." (Super.)

Aph. XI. Of many anatomical terms, the chief characteristics are antiquity, macrology, and unintelligibility.

Aph. XII. "Nomina . . . sesquipedalia, enunciatu difficilia vel nauseabunda, fugienda sunt." (Lacaze Duthiers.)

Aph. XIII. "All terms are, or ought to be, defined, and their signification in anatomy ought to be extended no further than these definitions allow of." (Barclay.)

Aph. XIV. "Ancient words are, by common consent, not necessarily used in scientific nomenclature with their precise original meaning." (Editor *New York Medical Journal*.)

Aph. XV. "The human mind wearies of too many names, and much more readily assimilates a new meaning for an old one." (W. H. Dall, letter to the writer.)

Aph. XVI. "Scientific truth must cease to be the property of the few. It must be woven into the common life of the world." (L. Agassiz.)

Aph. XVII. "The names which come nearest to be [illegible] accuracy of expression . . . are longest, most complex, least convenient, and least euphonious, and therefore are least adapted to common use." (Dr. E. R. Squibb.)

Aph. XVIII. Nothing is at once more desirable and more difficult than for the learned anatomist to revert, so to speak, to his long-past state of ignorance, and put himself in the place of one who undertakes to learn facts about unfamiliar organs and finds each new word an obstacle, and each needless synonym a pitfall.

Aph. XIX. "Every organ should have one name and but one only; and to that name the allusions contained in the names of its muscles, nerves, arteries, etc. [of its appended or distinctly collocated parts], ought to refer." (Barclay.)

Aph. XX. "Enfin, il a l'avantage de permettre de désigner sans changement d'adjectif les parties qui se rattachent à la description de cette circonvolution; [illegible] [illegible] [illegible]." (Broca.)

Aph. XXI. For the student or general reader, in one and the same publication, a single poor term is better than two good ones.

Aph. XXII. What is worth stating at all, is worth stating clearly.

Aph. XXIII. The four chief requirements of scientific writing should be clearness, consistency, correctness, and conciseness.

Aph. XXIV. Obscurity of style, in so far as it may be avoidable by devoting more time to composition, is a very offensive form of literary egotism.

Aph. XXV. "The best excuse . . . for the numerous terms of art [technical terms] actually used in anatomy . . . is that by the help of these, discourse is shortened by expressing in one word what must otherwise have been expressed in several, and for such things as must be mentioned very often such a liberty is not only allowable, but necessary." (Douglas.)

Aph. XXVI. "Those terms may surely be retained which are just and accurate, and not too long; those which assist us in discriminating objects; and those likewise, however absurd their original allusions, that, course of time, have laid aside their primary sense, and begun to be used as arbitrary names" (Barclay).

Aph. XXVII. "It is an old maxim accepted by the best logicians, that no name is so good as that which signifies the total idea or whole subject, without calling prominently to mind any one particular quality, which is thereby apt to be deemed, undeservedly, more essential than the rest" (Owen).

Aph. XXVIII. "The practice of anatomists of the soundest judgment has usually been, to transfer the anthropotomical name or phrase to the answerable part when detected in other animals. The objection that the original descriptive or otherwise allusive meaning of the term seldom applies to the part with equal force in other animals, and sometimes not at all, is one of really little moment; for the term borrowed from anthropotomy is soon understood in an arbitrary sense, and without regard to its applicability to the modified form which the namesake of the human bone commonly assumes to suit the ends required in the lower species. No anatomist, for example, troubles himself with the amount of resemblance to a crow's or other bird's beak in the 'coracoid' bone of a reptile, or with the want of likeness of the kangaroo 'coccyx' to the beak of a cuckoo; or of the whale's 'vomer' to a ploughshare; or ever associates the idea of the original mystic allusion of the anatomical term *sacrum* with his description of that bone in the megatherium or other monster. Common sense gratefully accepts such names when they become arbitrary, as *cat* or *calomel*, and when such concretes or adjectives as coccygeal, vomerine, and sacral can be employed to teach the properties or accidents of their subjects" (Owen).

Aph. XXIX. "The chief improvement which the language of anatomy, based upon that of anthropotomy, must receive in order to do its requisite duty, is the substitution of names for phrases and definitions; and this is less a change of nomenclature than the giving to anatomy what it did not before possess, but which is absolutely requisite to express briefly and clearly, and without periphrasis, propositions respecting the parts of animal bodies. Such names should be derived from a universal or dead language, and when Anglicized, or translated [adopted or paronymized ?] into other modern equivalents, ought to be capable of being inflected adjectively" (Owen).

Aph. XXX. "In proposing a definite name for each distinct bone, . . . I have sought earnestly to reduce the amount of reform to the minimum allowed by the exigencies of the case" (Owen).

Aph. XXXI. "In substituting names for phrases, I have endeavored, conformably with another of Dr. Whewell's canons (Aph. XVII., Op. cit., p. cxvii.) [see § 52], to approximate the sound of the name as nearly as possible to those of the leading terms of the definition or phrase, as *e.g.*, *alisphenoid* for '*ala media*, etc., *sphenoidalis*,' and for '*grande aile du sphénoïde*;' *orbitosphenoid* for '*ala superior seu orbitalis*, etc., *sphenoidalis*,' and for '*aile orbitaire du sphénoïde*'" (Owen).

Aph. XXXII. "I fully admit the inconvenience of any change in itself, and the mischief which ensues when affectation of precision of language takes the place of accurate knowledge of the objects of language. For the accomplished anatomist and physiologist names are scarcely of even secondary importance. But for the learner it is otherwise; and experience of the difficulties which ambiguous or misleading names occasion to students has led me to note down, from time to time during the last ten years, those points which I have found most troublesome, and which may be improved with the least amount of change" (Pye-Smith).

Aph. XXXIII. "The most important characters which nomenclature in anatomy, as in any other branch of science, ought to possess are *clearness and convenience*. Each object should have only a single name in use, and each name should be sufficiently distinctive" (Pye-Smith).

Aph. XXXIV. "A name should first, if possible, consist of a *single word*, for the reason just given, as well as for the practical advantage of brevity. Many anatomical terms, as *foramen lacerum medium basis cranii* and *iter e tertio ad quartum ventriculum cerebri*, are explanatory phrases which become intolerable when quoted habitually. Secondly, it should also be *capable of forming an adjective*. This is an additional reason against a binominal nomenclature. In the third place, every name should have its *Latin* as well as a vernacular equivalent. Besides euphony and flexibility in forming adjectives and compounds, the community of scientific interest among civilized nations makes this an indispensable rule. It is scrupulously followed by zoologists and botanists, with the best results, and its neglect by anatomists is always inconvenient" (Pye-Smith).

Aph. XXXV. New terms are, at best, necessary evils, hence their formation must be justified by something more than their logical or etymological correctness. They should present some advantage over existing terms in respect to brevity, or accuracy, or correlation, or capacity for inflection or euphony; and even all these should not warrant their introduction unless it were apparent that they were likely to be used somewhat often.

Aph. XXXVI. "Words—so innocent and powerless are they, as standing in a dictionary; how potent for good and evil they become to one who knows how to combine them" (Hawthorne).

Aph. XXXVII. "The Greek and Latin are both sanctioned in our present nomenclature; I should be inclined, notwithstanding the opprobrium attached by some to certain connections and intermarriages among harmless vocables, not to reject the co-operation of the two languages in any form, where experience shows it to be convenient, useful, or necessary" (Barclay).

Aph. XXXVIII. "Meaning does not exist in a word by virtue of its root or its history. The question is not what the word has stood for in the minds of persons long since dead, but what it stands for now in the minds of the living" (*Popular Science Monthly*).

Aph. XXXIX. "It is full of Latinisms, Gallicisms, Germanisms, and all isms but Anglicisms" (Lord Chesterfield).

Aph. XL. "The improvement of scientific speech thus far has been made under compulsion, for the most part by persons caring little, perhaps knowing little, of the rational laws of language; and has spawned a myriad of linguistic monstrosities that cannot live in the mouths of Christian, Pagan, or Jew. . . . What should be done is to make the technical terms grateful to the cultivated literary sense. . . . Then no one can read anything worth reading at first hand without learning these technicalities, and then the technicalities will be drawn into the popular speech and displace the old names and forms" (March).

Aph. XLI. "The happy facility for combination which the German language enjoys has long enabled the very eminent anatomists of that intellectual part of Europe to condense the definitions of anthropotomy into single words; but these combinations cannot become cosmopolitan; such terms as "*zwischenkiemendeckelstück*," are likely to be restricted to the anatomists of the country where the vocal powers are trained from infancy to their utterance" (Owen).

Aph. XLII. "By persons who commonly speak the English language, many of the commoner Latin words have ceased to be considered as foreign, and, except when combined with other Latin words or inflected according to Latin forms, are treated as English by adoption [paronyms]" (Dr. F. P. Foster).

Aph. XLIII. Either classicalism or vernacularism, either exoticism in nomenclature or esoticism, may be indulged so inconsiderately as to become a "fad." Nomenclature demands care and attention; but one must avoid becoming a *doctrinaire*. The "happy mean" should be maintained.

Aph. XLIV. It would be obviously unfair to ask the anatomists of other nationalities to adopt the vernacular names of any one modern tongue; but none of them can seriously object to technical terms derived from the dead languages, which are the source of so many of their common words.

Aph. XLV. "Technical terms of science should remain unaltered [essentially, i.e., should not be replaced by [illegible] heteronymes] in every translation" (Barclay).

Aph. XLVI. "Translation [heteronymy] blunts the [illegible]" (Charles Reade).

Aph. XLVII. "Scientific names, like the names of persons, should be available [by paronymy] in all languages" (Dal[illegible]).

Aph. XLVIII. In terminology, as in law, possession counts nine points. That which is may not be ideally perfect, but it is, *ipso facto*, endurable.

Aph. XLIX. All innovations are in some degree objectionable.

Aph. L. "Nowhere is prudence more necessary than in our attempts to innovate on habits and established customs" (Barclay).

Aph. LI. "Unfortunately, imagining that a principle, if right, could not be carried to too great a length, some anatomists seem to have forgotten the old, though just, observation of the poet, that

"'Est modus in rebus; sunt certi denique fines,
Ultra citraque nequit consistere rectum'"

(Barclay).

Aph. LII. "The question of encephalic nomenclature is of the highest importance. . . . The necessity of greater precision in our nomenclature is now recognized in all directions, and various special memoirs have been published upon the subject" (Duval and Keller).

Aph. LIII. "The older anatomists exhausted their ingenuity in inventing fanciful names for every feature of the brain, and as treated by the usual method of descriptive anatomy the mass of details has no more organic connection than a pile of jack straws has structure" (F. Baker).

Aph. LIV. "Die Anatomie hat es schon öfter anhören müssen dass sie eine arbitrare und prinziplose sprache spricht" (Hyrtl).

Aph. LV. "The nomenclature of the brain stands more in need of revision than that of any other part" (Pye-Smith).

Aph. LVI. "Il est bien certain qu'une nomenclature régulière est un grand moyen de simplification, dont l'utilite se manifeste surtout dans une étude aussi compliquée que celle du cerveau" (Broca).

Aph. LVII. "My object is not so much to get my own or any other set of terms adopted, as to urge the necessity for a reform in the nomenclature of the central nervous system and its cavities, a necessity which no comparative anatomist, especially if he be a teacher, can fail to see" (T. Jeffery Parker).

Aph. LVIII. "Whoever will carry out the application of [illegible] substantive terms [mononymns] to the homologous parts and structures of the encephalon, as they may be successively determined, will perform a good work in [illegible]" (Owen).

Aph. LIX. "I have no hesitation in saying that the labor of the anatomical student will be diminished fully one-half when this nomenclature shall have been [illegible] adopted" (Spitzka).

Aph. LX. "Are we to consider primarily the men who have worked . . . . or the men who are working now and who will work after we are gone?" (Bessey).

Aph. LXI. "A little present labor and the example of adoption, where the reasonableness and necessity of the reform are plain and undeniable, will much accelerate the future progress of anatomical science" (Owen).

Aph. LXII. "The medical profession is conservative, and no reasonable expectation can be entertained that the nomenclature now in use—with all its absurdities and imperfections—will be materially modified until a congress of teachers, convened for the purpose, agree upon a list of terms which will be introduced into the textbooks and which will be employed in teaching"* (H. Allen).

Aph. LXIII. "A new nomenclature is not to be classed with those important and brilliant discoveries . . . . It promises no immortality to its author, nor secures to his name any enviable mark of distinction. It is nothing more than what anatomists have long wished for, a desideratum which they have often attempted to supply by partial amendments. . . . It cannot pretend to instruct the learned or to give them new ideas of the animal structure . . . . and yet if it should facilitate the progress of study, and remove only a part of the rubbish that obstructs the journey, the author will consider his object as attained" (Barclay).

§ 44. The Merits of Organonyms. Aside from the aphorisms the foregoing pages are intended to present simply *facts* respecting nomenclature and etymology. In considering the relative advantages of names or sets of names the question naturally arises, How far should the adoption of a term depend upon the number or eminence of those who use it? Were we merely chronicling the past or providing for the present, it might well be claimed that the majority should prevail; that is, that a selection should be made of those terms that are in actual use by the largest number of leaders in anatomy; but, first, we are—or should be—thinking rather of the future, of the time indeed when our personalities shall have been forgotten, and when our memories shall be honored or the reverse, according to the evidence of disinterestedness in our action of to-day. In the second place, great anatomists may be poor linguists, and therefore be no real authorities excepting as mechanics are governed by tradition and rule of thumb. Thirdly, even though they may be linguistically accomplished, they may be careless or deliberately ignore the just claims of a correct terminology. Finally, they may have some "exclusive dogma," some nomenclatural whim or fancy which renders it almost impossible for them to take an unprejudiced view of matters.* In short, "witnesses are to be weighed, not counted," and the weight is to be assigned after a deliberate and impartial consideration of the subject from all sides.

§ 45. The writer asks a careful consideration of his plans for terminological improvement: because they are based upon an unbiased study of nearly all previous publications; because—as he has reason to think—during the last ten years he has given to the subject more time than has been given by any other anatomist, living or dead; because the linguistic principles involved have been approved by philological authorities; because the actual disturbance of the existing order of things is kept at the minimum; and because the practical availability of the terms has been demonstrated with hundreds of students in both a university and a medical school.

As contrasted with the vocabulary in common use (at least up to 1889), that which seems to the writer best calculated to facilitate the advancement and dissemination of accurate anatomical knowledge would consist of terms which are:

Designatory rather than descriptive.
Conservative rather than eradicating.
Impersonal rather than personal (eponymic).
Idionymic rather than homonymic.
Correlate rather than irrelate.
Coordinate rather than inco-ordinate.
Classical rather than vernacular.
Dissyllabic or trisyllabic rather than monosyllabic or polysyllabic.
Mononymic rather than polyonymic.
Monoglot rather than polyglot.
Paronymic rather than heteronymic.
Constant rather than varied.

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* At the meeting in September, 1888, [illegible] of American Anatomists [illegible] by the American [illegible] [illegible] Alexis [illegible]

* The following are examples of what may be [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] anatomy in fifteen [illegible] of two hours each.

§ 46. Advantages of Mononyms over Polyonyms.*—A. From the former, adjectives may be regularly derived; *e.g.*, from *callosum*, callosal; from *hippocampus*, hippocampal; from *thalamus*, thalamic. Notwithstanding the occasional introduction of verbal monstrosities like *pia-matral*, it is generally admitted that polyonymic adjectives are undesirable; indeed some writers, who still adhere to the polyonymic nouns, employ the mononymic adjectives.

B. Mononyms are readily compounded with other words; *e.g.*, *calloso-marginalis; subthalamicum;* such compounds could not well be formed from *corpus callosum* and *thalamus opticus*.

C. Mononyms are constant in form, excepting for the regular derivatives, numbers, cases, adjectives, and paronyms; whereas polyonyms are subject to variations of several kinds:

(*a*) By the omission of words; *e.g.*, *thalamus nervi optici* is commonly written *thalamus opticus*. The compound, *opto-striated body*, which occurred first in its French form, is ambiguous because the definite noun, *thalamus*, has been omitted, leaving the indefinite adjective *opto*, itself contracted from *optico*.

(*b*) By the conversion of qualifying words into other parts of speech; *e.g.*, the English translation (heteronym) of *pons Varolii* is *bridge of Varolius;* but *Varolian bridge* has also been employed.

(*c*) By the substitution of wholly different words for one or more of the components; *e.g.*, *commissura thalamorum*, *commissura mollis*, and *commissura intermedia* are liable to be used interchangeably; *medicommissura* is invariable.

(*d*) When a term comprises three or more words it is subject to permutation, *i.e.*, to the transposition of its components; *e.g.*, *Fissura occipito-parietalis* and *F. parieto-occipitalis;* these transpositions are, of course, more frequent among lengthy German combinations; the subject is also considered under the head of Pœcilonymy (§ 72).

(*e*) Polyonymic adjectives are subject to intentional, and even accidental, variation. The gyre designated by Owen as *subfrontal*, has been named *inferior frontal*, *infero-frontal*, and *inferofrontal*, *lower*, *first*, and *third*, as well as *Broca's*.

D. Mononyms may be more uniformly abbreviated. According to present methods, one and the same part, the *commissura anterior*, might be indicated upon figures by *c.a.* (Latin or French), *a.c.* (English), and *v.c.* (German); a single word like *præcommissura* would always have an abbreviation beginning *prc.* With the middle commissure, which is also known as the *soft*, the *gray*, and the *thalamic*, the opportunities for abbreviational diversity would be correspondingly numerous.

E. Aside from systematic abbreviation, polyonyms are subject to irregular and often inelegant abridgement. In one and the same paper occur *corpus callosum*, *corp. callosum*, *corp. callos.*, and, finally, *corpus*. In another, *corpus quadrigeminum*, *corp. quadrigem.*, *corp. quadrig.*, and *corp. quad.*; in a third, *tractus peduncularis transversus* is not merely abbreviated to *tr. ped. tr.*, but variously abridged to *tractus peduncularis trans.*, *tractus peduncl. tr.*, *tractus ped. trans.*, and *tractus ped. tr.*

F. Mononyms are usually shorter than the corresponding polyonyms. The prepositions *præ*, *post*, *sub*, *super*, *intra*, *extra*, *ento*, *ecto*, *medi*, *meso*, etc., are all shorter than the adjectives having the same force, viz., *anterior*, *posterior*, *inferior*, *superior*, *interior*, *exterior*, *ental*, *ectal*, *middle*, or *intermediate*. Hence there results from composition with them, not only the advantage of a mononym, but also the actual reduction in the number of letters and syllables. The following are examples of this reduction: *Præpedunculus* for *pedunculus anterior; postgeniculum* for *geniculum posterius; medicommissura* for *commissura media; subfrontalis* for *frontalis inferior; superoccipitalis* for *occipitalis superior*.

In this connection three points are to be observed:

1. The length of a term may be affected by (*a*) the number of words; (*b*) the number of syllables in each word; (*c*) the number of letters in each syllable.

2. One or two of these elements may be counteracted by the others; for example, although *corpus callosum* is a longer term than *callosum*, and *hippocampus* a longer word than *hippocamp*, and *bough* a longer word than *bow*, yet *indefatigability*, a mononym, is longer than the dionym *corpus callosum*, and the monosyllabic *though* is longer than the dissyllabic *also*. Hence, in any generalization respecting the length of terms, it is necessary to add, or understand, the qualification, "other things being equal," *ceteris paribus*, which may be abbreviated as *c.p.*

These generalizations are then as follows: Polyonyms are, *c.p.*, longer than mononyms. Polysyllables are, *c.p.*, longer than oligosyllables, *i.e.*, monosyllables, dissyllables, and trisyllables.

3. The written length of a term is affected by all three of the elements above named; but its spoken length is practically dependent upon only the number of words and syllables; *e.g.*, as written, *bough* and *eight* are longer than *bow* and *ate*, but as spoken they are equal.

G. A mononym is capable of adoption into any other language, either unchanged, or with so slight a modification as not to prevent its ready recognition. With most polyonyms, the transfer to either English or German involves either a change in the order of words; *e.g.*, when *thalamus opticus* becomes *optic thalamus;* or a change in the words themselves; *e.g.*, when *substantia cinerea* becomes *gray matter*. On this point see § 30.

§ 47. Between longer and shorter words there is merely a difference of degree, *e.g.*, *crus* and *pedunculus;* between a Latin word and its vernacular equivalent or heteronym (*e.g.*, *pedunculus* and *footlet*); or its paronym (*peduncle*) the choice might depend upon individual preference; but mononyms and polyonyms, terms of one word each and terms of two or more (*e.g.*, *pedunculus* and *pedunculus cerebelli*) differ in *kind;* it is not a question of size or euphony, but of essential endowment and capacity. The mononym is to the polyonym as is the water to the earth, or as is the bird to the tortoise.

§ 48. The desirability of replacing polyonyms by mononyms is in direct ratio with the frequency with which the part is mentioned, and with the need of employing corresponding adjectives. *Hypophysis* (formerly *pituitary body*) and *conarium* (formerly *pineal gland*) are much more frequently named since the discovery that the former has peculiar developmental relations with the pharynx, and the latter even more remarkable connections with a vestigial organ of sight. So long as the thin sheet of nervous tissue just dorsad of the chiasma was regarded as insignificant, and as occasionally absent, either *lamina cinerea* or *lamina terminalis* might not be so objectionable; but its now-admitted morphological importance as the cephalic boundary of the encephalic cavities justifies the use of the mononym, *terma*. The orifice left by the removal of the hypophysis and infundibulum had apparently received no name up to 1880; *foramen infundibuli* was a sufficiently appropriate descriptive term; but the frequency of its mention in notes respecting the preservation of the brain led the writer to discard it in favor of *lura*, at the same time that *alcohol-injection* was reduced to *alinjection* (after the analogy of *aldehyde* from *alcohol dehydrogenatus*).

§ 49. A good illustration of the principle that onymic improvement commonly attends any awakening of interest in parts, so that they are discussed by more persons or more frequently by some, is afforded by the prompt acceptance of Broca's arbitrary and sometimes Greek names, mostly unfamiliar and non-suggestive, for the various points on the head and skull which have to be recognized in operations involving the brain. In the last edition of "Gray," the editor gives very compact definitions of the mononyms *nasion*, *ophyrion*, *bregma*, *obelion*, *lambda*, *inion*, *basion*, *asterion*, *gonion*, *stephanion*, and *pterion*. Nor is it any valid objection to these new terms that, although only eleven in number, nearly one hundred words are required to define them.

The first two cervical vertebræ alone have mononymic titles; but were there similar anatomical, physiological, or aliquot occasions for specifying any other member of the vertebral series, a mononym would probably soon be proposed and generally adopted.*

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* For convenience, it is assumed that these are Latin, or in Latin form.

Mononymization seems to be hastened by the length of the principal word; e.g., of *membrana conjunctiva* the principal word is polysyllabic and the modifier *membrana* has been long and commonly dropped; but *pia* and *dura* are so short that the equally needless *mater* has not as yet proved burdensome to most writers. The case is analogous to the retention in English of the entire word *ultima*, while the longer *penultima* and *antepenultima* are abridged to *penult* and *antepenult*.

The following serves as a somewhat striking and nearly complete illustration of the comparative brevity of mononymic paronyms and polyonymic heteronyms: the phrase "*central gray substance of the aqueduct of Sylvius*" (employed by a distinguished experimental neurologist) might be reduced to *aquæductal cinerea*; nor is the marked diminution in length counteracted by any lack of intelligibility, for the term can be interpreted in only one sense.

§ 50. Increasing Use of Mononyms.—Whether consciously or unconsciously, there has been, during the present decade, a marked increase in the employment of single-word terms. Among the mononyms which may now be said to be in somewhat common use are *pons*, *thalamus*, *chiasma*, [illegible], *aqueduct*, [illegible], [illegible], *dura*, [illegible], [illegible], *hypophysis*, *striatum*, *callosum*, *fimbria*, [illegible] and *hippocampus*. In some cases also the appropriate adjectives are employed, e.g., *pial*, *dural*, *callosal*, [illegible], *hippocampal*, [illegible], and *pontile* (sometimes, incorrectly, *pontine* or *pontal*).

In a few encouraging instances, the introducer of a polyonym has himself been timely impressed with its undesirability, and has proposed an equivalent mononym. William Patten (*Journal of Morphology*, I., [illegible]) regards his [illegible] as "unsatisfactory on account of its length," and substitutes [illegible] therefor.

§ 51. Some of the new muscle names proposed by Coues and Shute (1887†) are truly mononyms (e.g., [illegible] and [illegible] for [illegible] and [illegible]); the majority (e.g., [illegible] for [illegible] [the writer's [illegible]]) are merely hyphenated dionyms. Besides attempting to simplify the names and reduce their length, the authors have grouped the muscles according to their nerve-supply, a basis of classification that commends itself theoretically, and proves practically available. But in undertaking to give all the members of a given group names of a special pattern, they have, as it seems to the writer, illustrated the disadvantages of "exclusive dogmas" in nomenclature. For the term [illegible] is [illegible] by the [illegible], [illegible] is retained, [illegible] is haplologized, and [illegible] is transposed into [illegible]. The writer cannot help feeling that this is a different [illegible] from his own [illegible], and [illegible] (W. and G., p. [illegible]), and that it is particularly unfortunate to encumber the often mentioned and only "popular" muscle, [illegible], especially if, as proposed by the authors, the biceps of the leg can be distinguished by a slight change of title.

§ 52. In reducing polyonyms to mononyms the retained word should be as distinctive as possible. Since any adjective may be used as a substantive, the choice should be determined by the desirability of retaining the word least likely to be misunderstood. For example, with [illegible], since the adjective is very common ([illegible], § [illegible]) and the noun does not occur in any other connection, the latter is retained as the mononym; but with [illegible] the noun is very common, and the adjective is retained and used as a noun. Where the choice is between two adjectives or other modifiers, that should commonly be retained which is [illegible] the more often used alone; e.g., [illegible] should be mononymized as [illegible] rather than as [illegible].

§ 53. When the noun and the adjective are equally distinctive, the choice may be made upon other grounds. With *appendix vermiformis* either part of the term would be sufficiently distinctive; the former is more commonly employed, although the latter occurs in a recent paper (Biggs, 1888); since, however, inflammation of the part has come to be designated quite generally as *appendicitis*, the noun will probably be retained.

§ 54. Locative Names.—As defined in § 13, these are terms indicating the location of organs; e.g., *posterior commissure*, *mesencephalon*, *precentral lobule*. As may be seen from the index of any anatomical manual, a very large number of organonyms indicate position.

Their advantages.—Most of the desirable information respecting an organ would be covered by the headings, *adult structure*, *development*, *function*, *discoverer*, *date of discovery*, *likeness*, *location*. Of course the first three are of the greatest intrinsic importance, but the information is seldom fully gained until long after the necessity for some kind of designation has led to the adoption of a name not altogether appropriate. Names commemorating a discoverer (eponyms, § 18) are undesirable (§ 59). There remains to be indicated the location or position of the organ; this is definite and suggestive as compared with the date or discoverer, and also much more readily determined than points of structure, development, or function. Furthermore, the location of an organ is a general and comprehensive attribute, and names which indicate it are commendable in accordance with the following opinion of Owen: "It is an old maxim accepted by the best logicians, that no name is so good as that which signifies the total idea of whole subject, without calling prominently to mind any one particular quality, which is thereby apt to be deemed, undeservedly, more essential than the rest."

Many geographical names are locative, the prefixes usually indicating the points of the compass. Most of them are polyonyms, e.g., *South Boston*, *East Boston*, etc.; but country names are sometimes combined as mononyms giving a complete series, like *Middlesex*, [illegible], *Sussex*, *Essex*, and *Wessex*. Among encephalic names these are nearly paralleled by *medicommissure*, *precommissure*, *postcommissure*, and *supracommissure*, *subcommissure* only being wanting.

§ 55. Locative Mononyms.—Most locative terms in common use consist of two or more words, the adjective indicating position being separate from the substantive or from the other adjective; e.g., *frontalis anterior*, *frontalis posterior*, [illegible]. In 1842 a large number of such polyonyms were mononymized by Owen, and terms like *postorbital* and *postfrontal*, *basisphenoid*, etc., were soon generally employed. Later, in the "Comparative Anatomy of Vertebrates," he introduced [illegible], [illegible], [illegible], [illegible] and [illegible], and a complete series of mononyms, largely locative, for the fissures and gyres. The classical names of the encephalic segments, *mesencephalon*, *metencephalon*, etc., are locative mononyms. Following these precedents, in 1873, the writer proposed to replace [illegible] and [illegible] by the locative mononyms [illegible] and [illegible],† and in 1881 formulated the general method of conversion as follows: "When two or more parts are similar, or have similar relations, to distinguish them by joining to some common title already in use prefixes indicative of their relative positions" (*Science*, p. 121, March 19, 1881). In all these terms *pre* and *post* signify, respectively, toward the head and toward the tail.‡

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* [illegible]

† [illegible]

* [illegible]

† [illegible]

‡ In most instances of the confusion caused by the employment of [illegible] [illegible] Vertebrates, [illegible].

§ 56. Formation of Locative Mononyms.—Two distinct questions are involved: (*a*), the selection of the substantive;[*] (*b*), the choice of the prefix. For example, the cerebellum is connected with other parts of the brain by three fibrous bundles at each side, continuous respectively with the pons, the mesencephal, and the postoblongata. How may they be most conveniently distinguished from other parts and from one another? Each has received many names; that which connects the cerebellum with the postoblongata has been known by at least twenty-three distinct Latin titles, besides many in other languages.

The Latin names are as follows: *Corpus olivare posterius; cp., pyramidale anterius; cp., pyramidale inferius; cp., pyramidale laterale; cp., pyramidale posterius; cp., restiforme; crus cerebelli ad medullam oblongatam; crus cerebelli descendens; crus cerebelli posticum; eminentia posterior bulbi rhachidici; eminentia pyramidalis; pars trunci medullæ cerebelli, qui pertinet ad partem posteriorem medullæ oblongatæ; processus a cerebello ad medullam oblongatam; prc. cerebelli ad medullam oblongatam; prc. cerebelli inferior; prc. cerebelli posterior; prc. cerebelli tertius; radix cerebelli; pedunculus chordæ spinalis; pdcl. medullæ oblongatæ; pdcl. cerebelli tertius; pdcl. cerebelli inferior; pdcl. cerebelli posterior.*[†]

§ 57. Among the substantives in the above list, *corpus* is so vague and common that it means nothing, and should be eliminated from all terms.[‡] *Eminentia* and *processus* more commonly refer to elevations with a free apex. The choice lies, therefore, between *crus* and *pedunculus*, which, also, are more commonly employed than the others. The latter is preferred on the following grounds:

1. It is more generally used in this sense; while *crus* is more commonly applied (as the Latin plural, *crura cerebri*) to the fibrous tracts between the pons and the chiasma.

2. There are two diverging crura, as the human legs form a pair; but there are three pair of peduncles, and the word less directly suggests the actual limbs.

3. Locative mononyms indicative of relative position, *præcrus*, *medicrus*, and *postcrus*, are less euphonious than *præpedunculus*, etc.[§]

§ 58. If the "pedunculus cerebelli posterior" be called *postpedunculus*, two corollaries naturally attend: 1, The other two "footlets" become respectively *medipedunculus* and *præpedunculus*; 2, the general name, *pedunculus*, should not be applied to other encephalic parts; *habena* is already replacing *pedunculus conarii*, and it is probable that a suitable mononym will be found for *pedunculus corporis callosi*. Even, however, without the above restriction, so that absolute explicitness might require the three cerebellar parts here under consideration to be named collectively *pedunculi cerebelli*, each of the three locative mononyms becomes a definite name or idionym; there may be many pedunculi, but only one pair of parts can now be called *postpedunculi*; the word has become an idionym, or name with a restricted application (see § 21).

3. *Crus* being no longer applicable to either of the cerebellar peduncles, it may be reserved as a mononymic substitute for *crus cerebri*; this latter is not merely a dionym, but actively misleading, inasmuch as it implies a direct connection with the cerebrum. When first introduced (in 1671, by Wharton), *cerebrum* included the thalami, and even the gemina, representing two other segments of the brain; but its present restriction to the prosencephal leaves the crura, the mesencephalic floor, connecting the epencephal with the diencephal. *Crus* is no longer needed for the columns of the fornix, and the less frequently mentioned supports of the olfactory bulbs may be called *olfactory crura* or *rhinocauls*. There will be many advantages in restricting *crus*, as an encephalic term, to the large and important fibrous tracts in question.

§ 59. Eponyms and Descriptive Terms.—These two groups of terms usually consist of more than one word, and may properly be considered here.

Disadvantages of eponyms. A. Anatomical names derived from the names of individuals are always polyonyms, and hence are objectionable on that score. Two other objections are mentioned by Pye-Smith: B. They are sometimes confusing; "the lymph-follicles of the spleen and the acini of the uriniferous tubules are alike called *corpora Malpighiana*."

C. Their meaning may be historically incorrect; "*Galvanism* is as unjust to Volta as *America* is to Columbus."

D. The association of an individual with some part discovered or described by him may be far from an honor that he would covet, since the tendency is to regard that as his only or at least principal achievement. This objection is recognized in the following comment in the London *Lancet*, November, 1882, upon *Listerism*: "It is unjust to so great a man for us to use his name in connection merely with a special means of dressing wounds. We consider Mr. Lister's work as far too great to be narrowed down to a mere matter of spray and gauze."

E. In some cases there may be an unjust, though inevitable, discrimination by reason of the length or cacophony of the discoverer's name.[*] Probably their most ardent admirers would hesitate to call parts after certain anatomists, who, nevertheless, have ample title to be so remembered.

F. Certain eponyms are needless, that is, the name of the individual is not required in order to render the term as a whole distinctive. So long, for example, as there is in the brain but one pons,[†] one insula, one aqueduct, and one torcular,[‡] there is no more need of adding the names of their discoverers or describers, than there would be of saying the *brain of Jones*, the *liver of Brown*, and the *cæcum of Robinson*, supposing those organs to have been discovered or named by those individuals.

From § 78, it will be seen that the writer has replaced the dionymic eponyms, *foramen Monroi*, *sulcus Monroi*, and *foramen Magendie*, by *porta*, *aulix*, and *metaporus*, respectively, these being mononyms of appropriate signification.

Among encephalic eponyms, however, there is one which no one thinks of discarding, viz., *fissura Sylvii*, the *Sylvian fissure*. This may be due partly to the doubt as to which Sylvius is referred to, so that the name has no distinct personal association, but mainly to the large number of compounds that have been applied to adjoining parts, *e.g.*, *presylvian*, *subsylvian*, *ectosylvian*, *supersylvian*, etc.; see especially, Owen, 1868, iii., pp. 136, 137.

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[*] With certain large groups of parts, fissures, gyres, arteries, etc., the entire name cannot be a mononym: a polyonymic adjective, however, may be mononymized by selecting a main adjective and combining it with a prefix (see § 25).

[†] Two other mononyms for the part in question have been suggested, though not insisted upon, by Spitzka. *Restibrachium* (*Science*, April 9, 1881, p. 165) is an admirable compound, and the same may be said of its correlatives, *pontibrachium* and *tegmentibrachium*; but *brachium* seems to have become well fixed upon parts of an adjoining segment, one of which (*brachium posterius = postbrachium*) is connected with the same (postgeminal) lobe as the tegmentibrachium, constituting a source of ambiguity. To *myelobrachium* (New York *Medical Record*, October 11, 1884, p. 395) there pertains the same objection as to *brachium*, and also there is the undesirable implication of an immediate macroscopic continuity with the myel, rather than with the oblongata.

[‡] There are about one hundred Latin encephalic names beginning with *corpus*; rid of them, neuronymy is relieved, lightened, literally disembodied.

[§] To offset these, there seems to the writer but one argument in favor of retaining pedunculus for the mesencephalic crus, viz., the existence of Gudden's name, *tractus pedunculi transversus*, for a band crossing the part; but even if this polyonym is not replaced by the writer's mononym, *cimbia*, it could easily become *tractus cruris transversus* with no lack of explicitness.

[*] Even had Ludovic Muggleton been inspired as he claimed, it is doubtful whether a sect of "Muggletonians" could have survived long in any cultivated community.

[†] *Pons Tarini* is an altogether obsolete synonym.

[‡] In this connection the writer desires to express his regret at having proposed (*New York Medical Journal*, March 21, 1881) to replace *torcular Herophili* by the obsolete synonym, *lenum*. Were the part newly observed, the latter term would be preferable on account of its brevity; but since the phrase has become familiar, the desired mononymization is best attained by merely dropping the superfluous genitive. Respecting the abandonment of *preoptic* and *postoptic lobes* for *pregeminum* and *postgeminum*, there may be some question; but a somewhat mature and unprejudiced consideration of the matter from all sides has induced the change: perhaps the most cogent reason is the willingness to perpetuate the essential element of the very common names, *corpus quadrigeminum* and *cp. bigeminum*.

§ 60. The objections to descriptive terms are two:

1. *Length*; e.g., *pneumogastricus*, [illegible] [illegible].

2. *Incompleteness*. It seems possible for chemists to indicate in a single word the entire composition of a substance; thus, for example, the full title of sulfonal is said to be *Diethylsulphondimethylmethan*; similarly, some surgical terms may be said to almost describe the procedure; an operation on the testicle is called [illegible]. In anatomy, excepting perhaps in German writings, names of such unwieldy lengths do not occur; one of the longest Latin names is incomplete as a descriptive title; *pneumogastric* is more than twice as long as *vagus*, the designative name of the same nerve, yet it falls of perfection as a descriptive term; it indicates only two of the six organs to which the nerve is distributed; to include them all the name should be *Nervus laryngo-pharyngo-pneumo-gastro-cardio-[illegible]*; which is as if antipyrine were known only as *dimethyloxyquinizine*. This matter is well stated by Barclay (1803, 161), referring especially to the proposition of Chaussier and Dumas to name all the muscles in accordance with their origin and insertion. "Such names are admirably calculated for muscles that have only a single origin and a single insertion; but where the origins and insertions are numerous, the name that pretends to enumerate the whole must run out to the length of a sentence;" e.g., for *Trapezius* we should have *Occipito-dorsi-clavi-acromi-scapularis* (this being a Latinization of Chaussier's descriptive term).

The most fatal objection to such descriptive names does not seem to have been considered by either of the French anatomists or by Barclay, viz., few if any muscles have the same attachments in other animals as in man; the biceps, for example, would be *coraco-gleno-radialis* in man, but *gleno-radialis* in the cat, where it has but one origin and thus but one head.* The ordinary name is accepted in a conventional sense, but a descriptive name would be at once remarked upon as not in keeping with the facts.

§ 61. It will be remarked that *postperforatus* (§ 58), although reduced from a polyonym to a mononym, is not only obviously a Latin word, but somewhat obtrusively so; upon an English page or in an English lecture its frequent recurrence has a savor of pedantry. In the writer's earlier terminological papers and in the first edition of "Anatomical Technology," this feature was noted in respect to the components of [illegible], etc.; but in the effort to accomplish the mononymization of a large number of polyonyms less attention was given to this aspect of nomenclature.

In the paper "Paronymy versus Heteronymy" (see § 5, note), this subject was fully discussed, and the conclusions are stated briefly in the preface to the second edition of the "Technology."

Admitting that certain Latin mononyms are so evidently Latin as to appear incongruous among ordinary English words, there are two alternatives, viz.: (1) to translate the objectionable words into the vernacular, to [illegible] them, [illegible] words be *heteronyms*; (2) to retain them essentially unaltered, but change their endings so as to appear less un-English; to convert them into *paronyms* (§ 59).

§ 62. *Objections to most Heteronyms*. Certain vernacular translations of Latin words are either inelegant in themselves or inappropriate to scientific writing; such are "tree of life" for *arbor vitæ*, "striped body" for *corpus striatum*, "bridge" for *pons*, "worm" for *vermis*, "little tongue" for *lingula*. An extreme example of heteronymic inappropriateness is offered by the name of a great French naturalist which might be translated "Baron [illegible]." If heteronymy is to be extended, there may be expected in time a treatise upon [illegible], with a peculiar [illegible] of the hinder [illegible] of the little brain."

But a much more vital objection to many heteronyms is that they unavoidably obtrude the literal sense and thence become more or less misleading or at least disturbing to the mind. As remarked by Whewell (Aph. XII., p. xv.), we may apply the term *cirrus* to a cloud composed of filaments even if those filaments are straight; but to call such a cloud a "curl-cloud" would be much less acceptable. "Great commissure" (as used for the callosum in Quain, II., 343) is sufficiently appropriate for the human brain; but the corresponding part in the opossum and some other marsupials is so small that its very existence has been denied in past years. The fifth digit of a pterodactyl supports most of the wing and is larger than all the rest together; hence "little finger" is strikingly inapplicable, but *minimus* much less forcibly suggests size. *Pia mater* is readily accepted, but the English heteronym, "kind" or "tender mother," like the German "fromme mutter," impresses one as needlessly literal.

Technical terms in science are comparable with certain conventional phrases in society; for example, "not at home" is commonly accepted as indicating either of several conditions which frustrate an intended call; but everyone has heard of embarrassments resulting from the literal rendering of the phrase, by ignorant servants, into "away from home," "not in the house," "has gone out," etc., all of which purport to state particular facts.

§ 63. Certain heteronyms are, however, unobjectionable, or, at least, practically ineradicable from most languages; e.g., *head*, *brain*, *hand*, *foot*, *kidney*, *heart*. Respecting most of these, it may be noted that they refer to parts either so exposed or so vital as to have claimed popular attention. They are like the domesticated animals, dog, cow, sheep, and some others whose vernacular names persist. But while *brain*, *Gehirn*, etc., are wholly unobjectionable by themselves, it does not follow that compounds, adjectives, and other derivatives should be formed therefrom. Conceding that this may be a matter for individual taste, after mature reflection, the writer concludes that *encephalic* is a convenient and appropriate adjective, and that *prosencephal* is preferable to *forebrain*. On this point Campbell comments as follows: "In Germany there is now a tendency to abolish Latin and Greek terms and substitute pure German words. In the German language this is possible, though, perhaps, not advisable. In English, however, *windpipe-head* [larynx], *woman-healing-art* [gynecology], and *straightgut-[illegible]* [illegible], would certainly be no improvement upon the technical terms now employed."

§ 64. The principal advantage of paronymization is, as it seems to the writer, that, while maintaining the general character of the modern language, the technical terms are, for the most part, so little changed from the Latin as to be at once recognizable, whether in the substantive or adjective form. With the Latin tongues, the change is very slight; *postperforatus* becomes *postperforé* in French and *postperforato* in Italian; in English it is *postperforate*; the German terms, [illegible] and [illegible], justify the retention of the Latin form; but *Postperforat* would have analogical precedent. Whichever form be used, the word never can be mistaken for any other, and the anatomist of every nationality may employ the form characteristic of his own language, with the certainty that it will be recognized by all other anatomists as equivalent to the common parent form, the Latin *postperforatus*.*

Correctly formed, paronyms also constitute a natural bond of continuity between the language of science and the language of every-day life, between the learned anatomist and the unprofessional, yet educated, man. The former uses certain vernacular nouns, *brain, heart, kidney, liver;* the latter can appreciate the significance of the technical adjectives, *encephalic, cardiac, renal,* and *hepatic,* only by becoming acquainted with the classical stems from which they are derived. Each makes a certain concession to the other.

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* [illegible]

* [illegible] "Paronymy versus Heteronymy," see § 5, note.

§ 65. Tendency to Brevity in Paronymization.—It will be noted that English paronyms often differ from their Latin originals in the less number of letters or of syllables, or both. As might be expected, however, these reductions have been applied more commonly to longer words.

§ 66. Methods of Paronymization.—The following are brief formulations of more common modes of converting Latin words into Anglo-paronyms.*

A. *Stomachus* = stomach. The ultima is dropped from the nominative, leaving the stem entire. Of this simple and common method of Angloparonymization, the following are familiar examples: *Organum* = organ; *cella* = cell; *oviductus* = oviduct; *canalis* = canal; *palpus* = palp; *tractus* = tract. The following have been employed by the writer as justified by the foregoing: *Hippocampus* = hippocamp; *myelon* = myel; encephalon = *encephal.*

B. *Nervus* = nerve.—The ultima becomes a silent *e.* Other familiar examples are *commissura* = commissure; *oliva* = olive; *fissura* = fissure; *polus* = pole. By analogy with the above the writer employs *gyre* from *gyrus; cœle* (especially in composition) from *cœlia; tele* (in composition only) from *tela; e.g., metacœle, metatele.*

C. *Musculus* = muscle.—A dissyllable is reduced to a monosyllable by the elision of the penultimate vowel, and the replacement of the ultima by a silent *e.* Also, *pedunculus* = peduncle; *diverticulum* = diverticle (used by Günther); *receptaculum* = receptacle.

D. *Decussatio* = decussation.—The ultima is dropped from the genitive (*decussationis*), leaving the stem, which is longer than the nominative. Also, *positio* (*positionis*), position.

E. *Ovarium* = ovary.—The three letters *ium* are replaced by *y;* a dissyllable by a monosyllable. *Aviarium* becomes aviary; *insectarium,* insectary,† etc.

F. *Eminentia* = eminence.—The termination *tia* becomes *ce.* Also, *absentia* = absence; *diligentia* = diligence; *substantia* = substance.

G. *Diaphragma* = diaphragm.—The ultima is dropped from the nominative, leaving less than the stem. (The word is from the Greek, the genitive is *diaphragmatis,* and the stem *diaphragmat.*) Other examples are *epigramma* = epigram; *programma* = program.

H. *Organismus* = organism.—A part of the ultima is dropped, and the rest is attached to the stem as what may be called a *hemisyllable.* Other examples: *chasma* = chasm; *aneurysma* = aneurysm; *columna* = column; *chiasma* = chiasm.

I. *Fibra* = fiber.—The ultima *ra* or *rum* becomes *er* (or *re?*). Also, *sternebra* = sterneber; *spectrum* = specter; *metrum* = meter. Notwithstanding its frequent use, the termination *re* is French, and should, so far as possible, be left to distinguish the paronyms in that language. There is no more reason why the regular English form, *meter*, should be discarded in favor of *metre*, than that we should use the German or Latin *metrum*, the Greek *μέτρον*, or the Italian *metro.*‡

J. *Præmaxilla* = premaxilla.—The diphthong *æ* becomes *e.* As stated in the Imperial Dictionary, the retention of the Latin form, *præ*, indicates that the word is "scarcely naturalized," *i.e.*, paronymized; *e.g.*, *fæces, cæcum.*

K. *Fœtor* = fetor.—The dipthong *œ* becomes *e.* This conversion is less well established than that of *æ* into *e.**

§ 67. In selecting the illustrations of paronymy, care has been taken to include only such as present but a single kind of modification. But many Angloparonyms, especially derivatives, present two changes; *e.g.*, *crista* = crest; *præcommissura* = precommissure; *aquæductus* = aqueduct.

§ 68. With all the above examples of Angloparonymy the English word is not identical with the Latin; there is a difference of orthography, a *literal* distinction between the two; the nominatives are obviously unlike.

But with many others which are commonly regarded as Latin words adopted or naturalized into English, the evidences of such adoption are less apparent, and may even be altogether absent, at least so far as regards the nominative singular, which is commonly regarded as the representative of a verbal form.

With the following, the nominative singular remains unchanged, but the plural has a distinctly English character; hence not only the plural, but also the singular nominative, may properly be regarded as Angloparonyms. Nominative singular (Latin or English), *animal;* plural, Latin, *animalia*, English, animals; *cadaver, cadavera*, cadavers; *enema, enemata*, enemas; *lens, lentes*, lenses; *hernia, herniæ*, hernias; *corolla, corollæ*, corollas; *pendulum, pendula*, pendulums; *atlas, atlantes*, atlases; *simile, similia*, similes. In the New York *Medical Record* for November 3, 1888, occurs *neurasthenias* for *neurastheniæ.*

With the following, not only the singular but also the plural nominative has practically been adopted from the Latin with no change in spelling, although the pronunciation may differ somewhat (see § 69, E):—*Cilium*, pl. *cilia; dictum*, pl. *dicta; memorandum*, pl. *memoranda* (or memorandums); *stratum*, pl. *strata.*†

§ 69. Other Evidences of Paronymization.—A word which is spelled exactly like the Latin may nevertheless be indicated to be a paronym, *i.e.*, an adopted word, in either of the following ways:

A. By simple declaration. B. By non-italicization. Were the rule that foreign words are to be italicized strictly followed, the non-italicization of a Latin term would show that the author regarded it as an unchanged paronym. C. By combination with words that are unmistakably of the author's language. This is most common with German writers. For example, *pedunculus* is primarily a Latin word, but in the compound *Pedunculusbahn* (Schwalbe, 1869, 614) it is obviously accepted as German. The following are analogous terms: *Quintuskern, Thalamusstiel, Cerebellumgebiet, Haubentractus.* Sometimes the two components are hyphenated. D. By the use of an oblique case or compound form. For example, instead of [illegible] it would be possible, though very unusual, to say the cerebellum's [illegible]; the use of a [illegible] would be [illegible] the cerebellum was considered as an unchanged paronym of the Latin. F. By pronunciation.—According to the Roman method of pronunciation the Latin c has the force of k before e and i as well as before a, o, and u; and the vowels a, e, i, and o have essentially the force of the English ah, â, ē, and ō. Hence, when employed as Latin a word may sound very differently from the same word employed in English. For example, in the Latin [illegible], the first word is pronounced in a certain way, but in the English [illegible] the same word has a different sound. In each case the language is indicated by the accompanying adjective, its form, and its position. The subject of what may be called *pronunciatio-paronymy* is admirably presented in the following extract from the preface to Foster's "Medical Dictionary" (p. xi): "The Roman method [illegible] is the one now taught in the leading universities of this country, and it will doubtless be adopted everywhere within a very few years. [illegible] Many of the commonest Latin words have ceased to be considered as foreign, and except when connected with other Latin words or inflected according to Latin forms, are treated as English by adoption [i.e., as unchanged paronyms]. [illegible] In some instances, e.g., *Abdomen*, a Latin or Latinized Greek word is so thoroughly adopted into English as in common use to have come to be pronounced as if it had a distinct English form." *Abdomen* is an instructive illustration of several points in paronymization, but, not being an encephalic term, need not be considered in this connection.

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* Certain etymological terms are here defined: *Ultima*, the last syllable. *Penult*, the syllable just before the last; the last but one. *Antepenult*, the syllable just before the penult; the last but two. For example, with *commissura*, *a* is the ultima; *sur*, the penult; *mis*, the antepenult. *Base*, the main or principal part of a derivative word; that which is neither prefix nor suffix, but which is qualified thereby. In the following words the basal element is italicized: *Dors*ad; post*nares;* medi*cornu;* pre*commissure;* ali*sphenoid.* (This use of the word *base* is suggested by Professor B. I. Wheeler.)

† This term was introduced by the writer's colleague, Prof. J. H. Comstock, in order to designate the first building erected for the experimental study of noxious or beneficial insects (*American Naturalist*, December, 1888, p. 1129).

‡ From the above it will be understood that the occurrence of the termination *re* in this article and in the others by the writer, is for the sake of conformity with the rules applying to the entire work.

* The learned editor of the *New York Medical Journal* and of Foster's "Medical Dictionary" (preface, p. x.) retains the diphthong, but the conversion into *e*, more common Latin form, is advocated by Professor Skeats (*Notes and Queries*); his remarks are approved and reinforced by the *British Medical Journal*, and quoted without adverse comment in the New York *Medical Record* for April 30, 1887, p. 500. Economy (from *œconomia*) and solecism (from *solœcismus*) are now never written *œconomy* or *solœcism*, and there seems to be no good reason why *diarrhœa* and *fœtus*, as English words, should not be written *diarrhea* and *fetus* (the latter, indeed, being the more common Latin form). In the writer's opinion, the *œ* should be retained only when it is desirable to distinguish two paronyms that otherwise might be confounded, as with those of *κήλη*, a tumor, and *κοιλία*, a cavity. The former can be Angloparonymized only as *cele* (at any rate, the perhaps permissible *kele* does not occur), *e.g.*, *varicocele, bronchocele*, etc.; *κοιλια* also *might* become *cele*, but the necessity for distinguishing the two (which had not occurred to the writer when his Cartwright lectures, *New York Medical Journal*, and *Medical Record*, February 9, 1884, *et seq.*, were reported, but was admitted a year later, *New York Medical Journal*, March 21, 1885, p. 326, note), justifies the retention of the diphthong. *Encephalocele*, then, is a tumor of the brain; *encephalocœle*, the brain cavity.

† Although the above Latin plurals may fairly be regarded as having been adopted into English, there is one reason for employing the regular English plural form, *ums*. In English the context does not, as in Latin, indicate the case; hence one sees not infrequently *septa, strata*, and *cilia* used as singular nouns of the first declension, and their plurals made *septæ, stratæ* and *ciliæ.*

When the changed paronym has already been adopted in common language, it is often better to employ the unchanged word in a desired special or technical sense. *Crest*, *pore*, and *hall* are changed Anglparonyms of *crista*, *porus*, and *aula*, but the latter words, as applied to special parts of the brain, are used unchanged, as English words without italicization.

§ 70. Homonyms (§ 22).—In most cases confusion from the use of homonyms is obviated by the context or by mental adjustment; the mind is set, as it were, at a particular level, and words are interpreted accordingly; it is comparable with the fact that in music one and the same symbol may stand for three sounds, D, D sharp, and D flat, according to the "key" in which the composition is written. There is, for example, no real danger of mistaking *brachium* (upper arm) for *brachium* (a ridge of the mesencephalon), or *pelvis* (a part of the skeleton) for *pelvis* (the cavity of the kidney); the parts are so distant or so different as to be unmistakable.

But homonyms applying to parts of a single organ, or to closely adjacent organs are highly objectionable, and should be disposed of either (a) by rejecting all of them, or (b) by adopting and confirming one to the exclusion of the rest.

For example, at least a score of encephalic parts have names into which *peduncle* enters; the writer proposes (§ 57) to restrict the word to the three fibrous connections between the cerebellum and other parts, viz., *prepeduncle*, *medipeduncle*, and *postpeduncle*. *Trans-* occurs in at least a dozen encephalic names; the writer would confine its application to the *fissura transversa*. *Rima* [illegible] and *rima* [illegible] constitute the "rima transversa" of Bichat; but the writer desires to employ *rima* alone for the [illegible].

Cornu.—This word has three distinct neuraxial applications: (A) To the hippocamp ("*hippocampus major*"); (B) to the medicornu ("middle or descending horn of the lateral ventricle"); (C) to the ventricornu (ventral or "anterior" extension of the myelic cinerea). The first is a curved elevation; the second is the curved cavity into which that elevation projects and a cast of which would be horn-shaped; the third is neither an elevation nor a cavity, but merely a curved area which appears upon transection of the myel. Since there are other parts of the body (thyroid bone, uterus, etc.) with which the same word is associated, it is desirable to restrict the encephalic applications, if possible. *Cornu Ammonis* is objectionable because it resembles an eponym and no beginner can be expected to know that Ammon, instead of an investigator, was an Egyptian deity with a ram's head; and because it is a dionym; so, of course, is *hippocampus major*; but if the postcornual ridge, formerly called *hippocampus minor*, be designated as *calcar*, then the "Ammon's horn" is adequately distinguished by *hippocampus* (Eng. *hippocamp*), a mononym.

The myelic cornua are strictly dorsal and ventral, and should be so named, rather than posterior and anterior; appropriate mononyms are *dorsicornu* and *ventricornu*, permitting the adjectives *dorsicornual* and *ventricornual*.

The three divisions of the paracœle ("lateral ventricle"), known commonly as anterior, middle, and posterior, may now receive the locative mononyms *precornu*, *medicornu*, and *postcornu*. These latter names, as mononyms, now become also idionyms, i.e., restricted in application. *Cornu posterius* might refer to either the dorsal ("posterior") horn of the myelic cinerea, or the caudal extension of the paracœle, to a surface or a cavity, to a part of the myel or a part of the brain; but *postcornu*, as introduced and defined by the writer in 1882 can hardly be applied to any other part of the neuraxis.

§ 71. Sinus.—This has had a very wide application, from a mere furrow on the ventral aspect of the pons to the pericardium, a closed cavity; at present so far as the head is concerned its use is restricted to three sets of cavities: (a) Spaces in the bones, e.g., the frontal sinuses, lined by mucosa and communicating with the air (Fig. 4684); (b) veins with relatively rigid walls, the longitudinal sinus, etc. (Fig. 4711); (c) irregular spaces between the pia and the arachnoid, the subarachnoidal spaces. The writer sees no way out of the existing ambiguity, and commends the considerate explanation offered in the last edition of Gray's "Anatomy," p. 167, note.

§ 72. Poecilonymy was contrasted in § 16 with terminological consistency. It may be defined as the use, in a given publication, whether by intent or through carelessness, of two or more terms, whether etymologically related or not, for one and the same object, attribute, or idea. Such discrepancies ("distinctions without differences") almost surely perplex the beginner, and may occasion doubts in the minds of even advanced students. The remark (from a neurological text-book) that certain fibers are called "*peduncular* because they are destined to pass into the *crusta cerebri*," is an explanation which explains nothing, to the student who has not learned that *crus* and *peduncle* are often employed interchangeably; the term appears simply as a *lucus a non lucendo*. Had Huxley, in the passage quoted (§ 5, *d*), gone on to speak of the elevation at the bottom of the Sylvian fissure as the "insula" in one place, as the "island of Reil" in a second, and as the "central lobe" in a third, and then defined a certain area as the paracentral lobule because it was opposite the central fissure, without stating that by *central fissure* was meant what he had called *fissure of Rolando* on one page, and *sulcus of Rolando* on another, and without adding that neither *central fissure* nor *paracentral lobule* implied any relation to the "central lobe," there would have resulted simply an unusually complete combination of poecilonymic ambiguities. Nor will such instances fail to occur until, before completing a given paper or treatise, the author decides what terms he will consistently employ as *the* names, all others being, so far as that publication is concerned, simply synonyms.*

§ 73. There seem to be two explanations of poecilonymy, viz.:

A. Intentional magniloquy, i.e., a style designed to impress the hearer or the reader with a sense of the speaker's or writer's mastery of the subject; this is so unworthy a motive that it may be dismissed with the commentary made in § 75 respecting the employment of ponderous Latin phrases.

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* As an example [illegible] the present [illegible] for the article on the [illegible] of the brain was prepared a printed alphabetical list of all the terms that were to be used.

B. The conscious or unconscious importation into science of a style which is justified, if at all, only by the generally accepted canons of what is called "literature," and thence the avoidance of that kind of repetition which renders (perhaps needlessly) legal documents so tedious.[*]

§ 74. In order to avoid what the writer calls "indirect pœcilonymy" (§ 17), adjectives, other inflectives, and compounds, referring to a part, should, in the same publication, be derived from the name employed for the part itself. If, for example, *epiphysis* is adopted as the substantive, *pineal* and *conarial* should be avoided; while if *conarium* is adopted as the substantive, *pineal* and *epiphyseal* should be introduced as synonyms only.[†]

§ 75. Magniloquy.—Akin to pœcilonymy is the employment of lengthy terms, especially in the Latin language, where shorter would suffice. Sometimes this is due merely to habit, but too often it seems to be intentional. A distinguished anatomist is portrayed at his lecture-desk, pointing to a diagram bearing one of the least commendable of encephalic polyonyms. Is not the persistence of certain ponderous names due to the willingness of some teachers and writers in human anatomy to impress their hearers or readers with a sense of their profound erudition? Is there not something here of the "*omne ignotum pro magnifico?*"[‡]

The phrase, *medical esotery*, is said to have been used by Simon for the mystery and secrecy supposed by ancient (and perhaps some modern) physicians to be necessary for the proper management of patients;[§] is it not possible that a kindred spirit of anatomical esotery induces some anatomists to employ needlessly long and impressive terms?

Astronomers have set an example in micronymy that anatomists might well follow; the first asteroid discovered was named *Ceres*, and many of its successors have dissyllabic or, at most, trisyllabic names. This is the more noteworthy, because, in the first place, these bodies are not, and are hardly likely to become, objects of popular discussion; and, secondly, each has its assigned numeric symbol, so that the professional astronomer need not employ the names at all. Now that the choice is offered, the anatomist who deliberately says *aponeurosis* for *fascia*, *anfractuosity* for *fissure*, and *convolution* for *gyre*, runs the risk of association, in the minds of others at least equally well-informed, with the "penny-a-liner," or the village orator who distinctly prefer *conflagration* to *fire*.[*]

§ 76. Perissology, or Needless Amplification.—The following is not, as might be supposed, from an elementary account of the nervous system for beginners, but from a special article by a distinguished neurologist, in a leading metropolitan medical journal: "The anterior column of gray matter extends throughout the spinal cord and the upper enlarged intra-cranial end of the spinal cord, which is known as the oblong cord or medulla (medulla oblongata)." Could not all of this information have been conveyed in something like the following sentence: "The ventral column of cinerea extends throughout the whole length of the myel and oblongata?" Here are fifteen words in place of thirty-two.[†]

§ 77. Linguistic Uniformity.—The interlarding of ordinary English writing or speech with needless French phrases is justly regarded as an affectation; is there not something of the same in the employment by scientific writers of ponderous Latin phrases when single words in English form are available? To a well-trained literary scholar, almost any page in existing neurological literature would be apt to suggest the bills of fare in second-rate hotels, a most unsavory compound of bad French with worse English, with this difference, that the steward has usually to mention an article but once upon the same occasion, whereas the anatomist has often to name the same part several times in the course of a few pages; hence, from a real need of condensation, and from a fancied need of an elegant style, there occur barbarous abbreviations and a use of synonyms which in no wise suggest each other.

§ 78. Absolute Innovations.—The following terms have been introduced by the writer[‡] with no direct precedent, ancient or modern, and solely for the sake of substituting mononyms for polyonyms: *torus* for *tuber cinereum; cimbia* for *tractus peduncularis transversus; lura* for *foramen infundibuli; aula* for the prosencephalic portion of the "third ventricle;" *porta* for *foramen Monroi; aulix* for *sulcus Monroi; metaporus* for *foramen Magendie.*

With the exceptions named above, all of the apparently new terms employed in the article Gross Anatomy of the Brain are justified by ancient or modern usage of either the terms themselves (*e.g.*, *cœlia* for an encephalic cavity) or some derivative, *e.g.*, *lamina cribrosa* and *lame criblée*, which suggest the metaphorical use of *cribrum* itself.

§ 79. Ventricle versus Cœle.—To the continuance of *ventricle* in the encephalic sense, there seem to the writer to be two serious objections, and two others which, although real, are not of much weight.[§]

The serious objections are: 1, The word cannot be compounded with prefixes distinctive of the encephalic names, so as to form mononyms, without a very undesirably prominent hybridism; *prosoventricle* is as harsh as *prosocœle* is acceptable; 2, the word is indissolubly asso-

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[*] The following verses (source unknown to the writer) are of course a gross caricature of literary pœcilonymy, but on that account they serve to illustrate the point in qnestion more completely:

Behold the mansion reared by dædal Jack.
See the malt stored in many a plethoric sack,
In the proud cirque of Ivan's bivouac.
Mark how the rat's felonious fangs invade
The golden stores in John's pavilion laid.
Anon with velvet foot and Tarquin strides,
Subtle Grimalkin to his quarry glides,
Grimalkin grim, that slew the fierce rodent,
Whose tooth insidious Johann's sackcloth rent.

* * * * *

Here stalks the impetuous cow with crumpled horn,
Whereon the exacerbating hound was torn,
Who bayed the feline, slaughtered beast, that slew
The rat predacious, whose keen fangs ran through
The textile fibres that involved the grain
Which lay in Hans' inviolate domain.

* * * * *

The loud, cantankerous Shanghai comes at last,
Whose shouts arouse the shorn ecclesiast,
Who sealed the vows of Hymen's sacrament
To him, who, robed in garments indigent,
Exosculates the damsel lachrymose,
The emulgator of that horned beast morose,
That tossed the dog, that worried the cat, that kilt
The rat, that ate the malt that lay in the house that Jack built.

[†] It is possible, however, to carry terminological correlation too far; the not unnatural use of *thalamencephalon* and *thalamocœle* for the shorter *diencephalon* and *diacœle*, in order to connect the segmental and cavitary names with the names of the chief masses, may lead some apostle of absolute consistency to insist upon *cerebellencephalon* and *cerebellocœle*, or upon *quadrigeminal ventricle.*

[‡] "While words of learned length and thundering sound
Amazed the gazing rustics ranged around."

[§] See the naïve remark respecting *neurasthenia* reported in the New York *Medical Record*, November 3, 1888, p. 547.

[*] There seems to be no reason why *habena* should not replace *habenula* and *sclera*, *sclerotica*; on the same grounds the cerebellar interval now called *vallecula* (properly *vallicula*, although the former occurs in the article Gross Anatomy of the Brain) may well be named *vallis*.

[†] Some of our anatomical writers would do well to heed the following vigorous commentary upon verbiage in another profession, reported to have been uttered by Hon. David Dudley Field, after showing that more than nine hundred words are used in a deed where two hundred would answer all purposes:—"They beget and confirm our dreadful habits of verbosity; they make the young lawyers think that these words and phrases mean something, and thus teach falsehood: they lead the minds of old and young to run in grooves: they encumber, and because they encumber, they tend to hinder, obscure, and confuse; they make it necessary to write, read, and record, in the course of a year, millions upon millions of useless words, all of which cost a great deal of time and a great deal of money."

[‡] The locative mononym, *intercalatum*, for *locus niger*, is used in the article Gross Anatomy of the Brain, but it was suggested by Spitzka.

[§] It is longer than *cœle*, whether letters or syllables be considered; it applies also to cardiac cavities and to a laryngeal recess, and has been sometimes used for stomach; but, as discussed under § 70, ambiguities of this kind are unavoidable, and are not, as a rule, practically confusing.

The following Table contains a sufficient number of representative, complete terms to enable the reader to estimate the degree and kind of modification involved (1) in substituting mononyms for polyonyms and (2) in framing from the Latin mononyms paronyms conforming to the "genius" of each modern language. The Latin polyonyms and the French, German, and Italian paronyms are in italics. The preferred Latin mononyms are in heavy-faced type. The preferred English paronyms are in small capitals. The English heteronyms are in ordinary type. The section numbers refer to general remarks in the text of this article. The other references are to footnotes upon page [illegible]. For all errors the writer alone is to be held responsible.

LATIN. (Polyonyms in upper line.) Mononyms	Genitive	Plural nominative	Adjective	ENGLISH. (Heteronyms in upper line.) Singular	Plural	Adjective	French, German, Italian
	Substantia alba (§ 12).			White (or medullary) matter.			
Alba	Albæ		Albalis	ALBA		ALBAL	[illegible]
	Membrana arachnoidea (§ 8).			Arachnoid membrane.			
Arachnoidea.	Arachnoideæ.	Arachnoideæ	Arachnoidalis.	ARACHNOID.	ARACHNOIDS.	ARACHNOIDAL.	[illegible]
	Arbor vitæ cerebelli (§ [illegible]).			Tree of life.			
Arbor	Arboris	Arbores	Arboreus	ARBOR	ARBORS	ARBOREAL	[illegible]
	[illegible] (§ [illegible]).			Cephalic part of third ventricle (p. [illegible]).			
Aula	Aulæ.	Aulæ.	Aulicus	AULA (§ [illegible]).	AULAS	AULIC	[illegible]
	Hippocampus minor, Calcar avis (§§ [illegible]).			Lesser hippocampus.			
Calcar	Calcaris.	Calcaria.	Calcarinus	CALCAR.	CALCARS.	CALCARINE.	[illegible]
	Corpus callosum (§ [illegible]).			Hard body (§ [illegible]).			
Callosum	Callosi.	Callosa	Callosalis.	CALLOSUM	CALLOSUMS.	CALLOSAL.	[illegible]
	Nucleus caudatus (§ [illegible]).			Caudate body or nucleus.			
Caudatum.	Caudati.	Caudata	Caudatalis	CAUDATUM	CAUDATUMS.	CAUDATAL.	[illegible]
	Tractus transversus pedunculi (§ [illegible]).			Transverse band of cerebral peduncle.			
Cimbia	Cimbiæ	Cimbiæ	Cimbialis	CIMBIA	CIMBIAS.	CIMBIAL.	[illegible]
	Substantia cinerea (§ [illegible]).			Gray matter.			
Cinerea	Cinereæ		Cinerealis	CINEREA		CINEREAL.	[illegible]
	Corpus pineale (§ [illegible]).			Pineal body.			
Conarium	Conarii	Conaria	Conarialis	CONARIUM	CONARIUMS.	CONARIAL.	[illegible]
	Crus cerebri, *Pedunculus cerebri* (§§ [illegible]).			Cerebral crus.			
Crus	Cruris.	Crura.	Cruralis.	CRUS	CRURA	CRURAL.	[illegible]
	Thalamencephalon (§ [illegible]).			Tween-brain.			
Diencephalon	Diencephali.	Diencephala	Diencephalicus	DIENCEPHAL	DIENCEPHALS	DIENCEPHALIC.	[illegible]
	Ventriculus tertius (§ [illegible]).			Third ventricle (p. [illegible], § [illegible]).			
Diacœlia	Diacœliæ	Diacœliæ	Diacœlianus	DIACŒLE.	DIACŒLES.	DIACŒLIAN.	[illegible]
	Tela choroidea ventriculi tertii (§ [illegible]).			Membranous roof of third ventricle.			
Diatela	Diatelæ	Diatelæ	Diatelaris	DIATELA	DIATELAS	DIATELAR.	[illegible]
	Plexus choroideus ventriculi tertii (§ [illegible]).			Plexus of third ventricle.			
Diaplexus	Diaplexus	Diaplexus	Diaplexalis	DIAPLEXUS.	DIAPLEXUSES.	DIAPLEXAL.	[illegible]
	Dura mater (§ [illegible]).			Hard mother (§ [illegible]).			
Dura	Duræ	Duræ	Duralis	DURA	DURAS	DURAL.	[illegible]
	Corpus fimbriatum (§ [illegible]).			Fringed body.			
Fimbria	Fimbriæ	Fimbriæ	Fimbrialis	FIMBRIA.	FIMBRIAS.	FIMBRIAL.	[illegible]
	Corpora quadrigemina (§§ [illegible]).			[illegible]			
Geminum	Gemini	Gemina	Geminalis	GEMINUM.	GEMINUMS.	GEMINAL.	[illegible]
	Corpus geniculatum (§ [illegible]).			Geniculate body.			
Geniculum	Geniculi	Genicula	Genicularis	GENICULUM	GENICULUMS.	GENICULAR.	[illegible]
	Pedunculus conarii (§ [illegible]).			Peduncle of the pineal body (§ [illegible]).			
Habena	Habenæ	Habenæ	Habenalis	HABENA.	HABENAS.	HABENAL.	[illegible]
	Hippocampus major (§ [illegible]).			Ammon's horn (§ [illegible]).			
Hippocampus	Hippocampi.	Hippocampi.	Hippocampalis.	HIPPOCAMP.	HIPPOCAMPS.	HIPPOCAMPAL.	[illegible]
	Corpus pituitarium, Glandula pituitaria (§ [illegible]).			Pituitary body (§ [illegible]).			
Hypophysis	Hypophysis	Hypophyses	Hypophysealis	HYPOPHYSIS.	HYPOPHYSES.	HYPOPHYSEAL.	[illegible]
	Insula Reilii (§ [illegible]).			Island of Reil.			
Insula	Insulæ	Insulæ	Insularis	INSULA.	INSULAS.	INSULAR.	[illegible]
	Commissura mollis (§§ [illegible]).			Middle commissure (§§ [illegible]).			
Medicommissura.	Medicommissuræ.	Medicommissuræ	Medicommissuralis	MEDICOMMISSURE	MEDICOMMISSURES	MEDICOMMISSURAL.	[illegible]

Latin. (Polyonym in upper line.)				English. (Heteronym in upper line.)			French. German. Italian.
Nom. singular.	Genitive.	Nom. plural.	Adjective.	Singular.	Plural.	Adjective.	
Nucleus lenticularis s. Corpus lentiforme (§ 11).				Lens-shaped body.			
Lenticula.	Lenticulæ.	Lenticulæ.	Lenticularis.	LENTICULA.	LENTICULAS.	LENTICULAR.	*Lenticule.* *Lentikel.* *Lenticula.*
Foramen infundibuli (§ 48).				Infundibular orifice.			
Lura.	Luræ.	Luræ.	Luralis.	LURA.	LURAS.	LURAL.	*Lure.* *Lura.* *Lura.*
Foramen Magendie (§ 78).				Foramen of Magendie.			
Metaporus.	Metapori.	Metapori.	Metaporalis.	METAPORE.	METAPORES.	METAPORAL.	*Metapore.* *Metapór.* *Metaporo.*
Medulla spinalis.				Spinal cord.			
Myelon.	Myeli.	Myela.	Myelicus.	MYEL.	MYELS.	MYELIC.	*Myel.*[18] *Myel.*[19] *Myello.*
Axis cerebro-spinalis (§ 19).				Cerebro-spinal axis.			
Neuraxis.	Neuraxis.	Neuraxes.	Neuraxialis.	NEURAXIS.	NEURAXES.	NEURAXIAL.	*Neuraxe.* *Neuraxe.*[20] *Neurasse.*
Medulla oblongata (§ 52).							
Oblongata.	Oblongatæ.	Oblongatæ.	Oblongatalis.	OBLONGATA.	OBLONGATAS.	OBLONGATAL.	*Oblongate.* *Oblongate.* *Allungato.*
Fissura occipito-parietalis (§ 23).				Occipito-parietal fissure (§ 46, *d*).			
Occipitalis.	Occipitalis.	Occipitales.	....	OCCIPITAL F.	....	....	*Occipital.* *Occipital.* *Occipitale.*
Corpus olivarium (§ 11).				Olivary body.			
Oliva.	Olivæ.	Olivæ.	Olivarius.	OLIVA.	OLIVAS.	OLIVARY.	*Olive.* *Olive.* *Oliva.*
Ventriculus lateralis (§ 80).				Lateral ventricle.			
Paracœlia.	Paracœliæ.	Paracœliæ.	Paracœlianus.	PARACŒLE.	PARACŒLES.	PARACŒLIAN.	*Paracœlie.* *Parakölie.* *Paracœlia.*
Pons Varolii (§ 59).				Varolian bridge (§ 46, *b*).			
Pons.	Pontis.	Pontes.	Pontilis.	PONS.	PONSES.	PONTILE.	*Pont.* *Pons.* *Ponte.*
Foramen Monroi (§ 59, F).				Foramen of Monro.			
Porta.	Portæ.	Portæ.	Portalis.	PORTA (§ 78).	PORTAS.	PORTAL.	*Porte.* *Pfort.* *Porta.*
Locus perforatus posticus (§ 78).				Posterior perforated space.			
Postcribrum.	Postcribri.	Postcribra.	Postcribralis.	POSTCRIBRUM.	POSTCRIBRUMS.	POSTCRIBRAL.	*Postcrible.*[21] *Postcribrum.* *Postcribro.*
Pedunculus cerebelli posterior (§ 56).				Posterior peduncle of cerebellum.			
Postpedunculus.	Postpedunculi.	Postpedunculi.	Postpeduncularis.	POSTPEDUNCLE.	POSTPEDUNCLES.	POSTPEDUNCULAR.	*Postpéduncule.* *Postpedunkel.* *Postpeduncolo*
Brachium conjunctivum anterius (§ 56).							
Præbrachium.	Præbrachii.	Præbrachia.	Præbrachialis.	PREBRACHIUM.	PREBRACHIUMS.	PREBRACHIAL.	*Prebrachion.* *Prebrachium.* *Prebraccio.*[22]
Cornu ventriculi anterius (§ 70).				Anterior horn of lateral ventricle.			
Præcornu.	Præcornu.	Præcornua.	Præcornualis.	PRECORNU.	PRECORNUS.	PRECORNUAL.	*Precorne.* *Präcorn.* *Precorno.*
Gyrus frontalis inferior (§ 46, C, *e*).				Broca's, or lower frontal, convolution (§ 46, *e*).			
Subfrontalis.	Subfrontalis.	Subfrontales.	....	SUBFRONTAL G.	....	....	*Subfrontale.*[23] *Subfrontal.* *Subfrontale*
Lamina terminalis s. cinerea (§ 48).				Terminal lamina.			
Terma.	Termatos.	Termata.	Termaticus.	TERMA.	TERMAS.	TERMATIC.	*Terme.* *Term* (?) *Terma.*
Thalamus nervi optici (§ 40, C, *a*).				Optic thalamus.			
Thalamus.	Thalami.	Thalami.	Thalamicus	THALAMUS.	THALAMI.	THALAMIC.	*Thalame.* *Thalam.* *Talamo.*
Tuber cinereum (§ 78).				Gray protuberance.			
Torus.	Tori.	Tori.	Toralis.	TORUS.	TORI.	TORAL.	*Tore.* *Tor.* *Toro.*

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[1] *Album* is given by Littré as a Latin word adopted into French, but *alb* would have a more Gallic sound.

[2] According to Heyse's "Worterbuch" *arachnoida* is the encephalic and *arachnoide* the ocular form.

[3] *Aule* may be regarded as the unrealized substantive of *aulique*.

[4] Although the French for *calcaire* appears to have been used already, only as if from *calcarius* (chalky), there seems to be no reason why the same word should not be derived from *calcar*, a spur.

[5] *Cimbia* may be derived from *κῦμα*, a small wave, through the Latin *cyma*. *Central* and its compounds are written by Guldberg, *zentral-furche, postzentral, präzentral*, etc.; some, therefore, may write *zimbia* and *zinerea* for *cimbia* and *cinerea*.

[6] *Conarion* is used by Chaussier and Paré, but the termination *um* occurs in the French Dictionary.

[7] The retention of the *K* is not only in accordance with the present tendency of German writers but justified by *enkephalgisch*, to which the writer's attention was called by Professor W. T. Hewett, who suggests also that the more numerous forms, *encephalgie, encephalalgie, encephalologie, encephalotomie* must have come through the French. The Germanization of the termination *alum* of *encephalum* by dropping the ultima is analagous to the reduction of *epithelium* and *diverticulum* to *epithel* and *divertikel*.

[8] The French *cœliaque* warrants *cœlie*.

[9] The Italian *celiaca* represents the Latin *cœliaca*, but the non retention of the diphthong throws upon the context the distinction between a tumor and an encephalic cavity; see § 66, K, note.

[10] The common French form is *jumel*, but there seems to be no serious objection to *géminé*.

[11] *Genicoli* was found in the plural only, but the singular is analogous to the Latin *geminum*.

[12] *Habena* is used by Inzani, and *hippocampo* by Giacomini; several other Italian words now retain the initial aspirate.

[13] The writer has withdrawn *hypocampa* (*N. Y. Med. Jour.*, March 28, 1885, p. 356, note), in accordance with Spitzka's suggestion that the frequent occurrence of *hypocampe* in Vicq d'Azyr was a typographical error.

[14] *Hypophyse* occurs in German compounds used by Schwalbe and others.

[15] The French *ile* is the result of repeated contractions; the adjective *insulaire* may be regarded as derived from an unrealized *insule*; § 42.

[16] Although the usual Italian paronym of *insula* is *isola*, Giacomini's phrases *l'insula, dell'insula*, and *all'insula* seem to indicate the adoption of the Latin word unchanged.

[17] *Medicommissure* (rather than *mediocommissure*) seems justified by *medifourche* and *mediastin*.

[18] The ordinary Galloparonym of *myelon* is *mœlle*, but *myél* seems warranted by *myélite*, and by *myélaxe* and *myélencéphale*.

[19] No German compound of *myel* has been found by the writer, but such terms as *myasthenie* and *myologisch* may be sufficient precedents for retaining the Y.

[20] *Neuraxe* is justified by *Neurorohr* and *Neuralgtaschicht*, and by *Erdaxe* and *Himmelaxe*.

[21] The prefix *post* is adopted into the French *postpéduncule*, and *postabdomen*.

[22] *Brachiale* seems to warrant *brachio*, rather than *braccio*.

[23] *Subfrontal* and other compounds of *sub* have precedents in *subalterne, substance*.

[24] *Diatela* and *diaplexus* are practically contractions of *diencephalic tela*, and *plexus*, the prefix having the force of the entire segmental name; compare *aldehyde*, § 48.

[25] *Pituitary body* is objectionable, not as based upon an error respecting the source of the nasal mucus, but because it is a polyonym, § 46.

[26] With several of these terms a second English paronym would be legitimate, *e.g.*, *diacœlia, diatele, diaplex, hippocampus, lenticle, myelon, olive*; see § 40; *lingula* and *lingule* would both be good English words.

ciated with the ordinals, *third*, *fourth*, and *fifth*, which are not only unhelpful but positively misleading.

Had it chanced that the several encephalic cavities had been enumerated like the encephalic vesicles, from first to fifth, or even (assuming that the entire oblongata, cerebellum, and pons constitute a single segment) from first to fourth, it is probable that these numerical designations would be forever left undisturbed, notwithstanding they would have had no obvious correlation with the segmental names, and would have been [illegible] and incapable of inflection.

But the current ventricular designations are as meaningless and misleading as if the cervical vertebræ were named as follows: *First* and *second* are applied to the lateral masses ("wings") of the atlas and the neural, connecting part ignored; the axis (second) is then called "third;" the actual third (supposing it to be small in the adult) is called a "process" or "isthmus;" the fourth and fifth, being fused, are called "fourth;" finally, the hyoid bone is named "fifth" because, although in no sense a vertebra or originally part of the series, it is at least a bone and must be designated in some way.

Were it possible or desirable to exclude from the minds of students at the present day all knowledge of development and comparative anatomy, teachers might, with some hope of success, continue to enumerate the encephalic cavities as *first*, *third*, etc., "ventricles;" but as it is, they are compelled, in the interests of logic and even common sense, to stop and explain that there is no true relation whatsoever between these antiquated, anthropotomical ventricular designations and the facts of embryology and comparative anatomy which, sooner or later, would be presented.

Under these circumstances, is it worth while to continue the solemn farce of affirming a thing and denying it in the same breath? Is it not actually easier to discard the old names once and for all, as having indeed scarcely a historical value, and simply combine the fairly well-established segmental prefixes with the single short word, which was indeed employed by the Greeks in the very sense now independently revived?

§ 80. In favor of *cœle* (Lat. *cœlia*, from Gr. κοιλία), in place of *ventricle* for the encephalic cavities, may be urged the following arguments, some direct, others indirect:

1. It is a word of Greek origin and thus regularly compatible with the characteristic prefixes already employed in the segmental names; mesocœle, epicœle, etc., are terms both correct and euphonious.

2. It has strictly classical authority for use in the sense of an encephalic cavity.*

3. It has been at recent times independently proposed by two anatomists, teachers as well as investigators.†

4. It has been adopted, more or less completely, by three distinguished neurologists: H. F. Osborn, E. C. Spitzka, and R. Ramsay Wright.‡

Assuming that *cœle* is gradually to replace *ventricle* as a general term for the encephalic cavities,* how shall the several divisions be distinguished? After carefully considering his own propositions and those of T. J. Parker, the writer concludes that the original and natural plan is the best, viz., to simply transfer to *cœle* the characteristic Greek prefixes by which the five commonly accepted segments are designated (see pp. 114 and 125 of this volume); this gives a series of terms which may be tabulated as follows:

Segments.	Cavities.	Ordinary designations.
Prosencephal	Procœle	[illegible]
Diencephal	Diacœle	[illegible]
Mesencephal	Mesocœle	[illegible]
Epencephal	Epicœle	[illegible]
Metencephal	Metacœle	[illegible]
Myel	Myelocœle	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]
[illegible]			

§ 81. **Terms Indicating Relations of Resemblance or Identity between Organs.**—In § 1, B, C, and D, occur the phrases *similar to*, *corresponds to*, and *represented by*. In like manner it might be said that the hand of man is *represented* by the paw of the cat, but that the spots on the peacock's tail feathers are *similar* to eyes. When the resemblance is a superficial, or merely functional one, and does not involve any real, structural unity, the parts are said to be *analogous*, and the relation is one of *analogy*; but when, with or without such resemblance, the parts agree in structure, in connections, and in mode of development, they are said to be *homologous*, and their relation is one of *homology*. There are several kinds and degrees of homology; for example, the manus and pes are not only similar in form and therefore analogous, but also nearly identical in structure, and therefore homologous; but this is like the homology between the right and left hands, rather than the relation of parts of two individuals. For further discussion and definitions of these and kindred terms, see works upon Comparative Anatomy, especially Owen (1866), and Gegenbaur (1878); also Geddes' article "Morphology," *Encyclopædia Britannica*, and the writer's papers "On Morphology and Teratology," *Bost. Soc. Nat. Hist.*, *Memoirs*, I., [illegible], and "Intermembral Homologies," *Bost. Soc. Nat. Hist.*, *Proceedings*, xiv., pp. 154–242.

§ 82. **Concluding Remark.**—Aside from prejudice and lack of practical direction as to removing, preserving, and examining the organ, there is but one valid reason why every child of ten years should not have almost and somewhat extended personal acquaintance with the gross anatomy of the mammalian brain; that obstacle is the enormous and unmanageable accumulation of objectionable names under which the parts are literally buried.

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* [illegible]

† [illegible]

‡ [illegible]

* Excepting for the sake of particularizing or to avoid ambiguity, [illegible] § 68.

† For convenience the entire "fourth ventricle" may be called [illegible]

‡ Between the aula and each procœle is an orifice, the porta or foramen of Monro.

§ Between the [illegible] and each [illegible] is an orifice, the [illegible]

‖ The dorsal extension of "third ventricle" [illegible] by Parker, [illegible]

The anatomists of to-day have an opportunity of providing for the future while cherishing the past; of benefiting posterity without neglecting ancestors; of lightening the burdens of generations to come, while recognizing the value of what was done by the anatomical fathers; of erecting a terminological monument in which the best of what has been is cemented by their own labors.*

TOPONYMY.

§ 83. For the definition of toponymy as referring to descriptive terms, see § 1. The present division of the article consists mainly of an enumeration of toponyms, and of their equivalents and synonyms as used by various writers. The principal difficulties arise from the not unnatural transfer of terms applicable only to the erect human body, to quadrupeds or other vertebrates having a horizontal attitude. As well remarked by Wright, "much confusion has been caused by importing into comparative anatomy terms employed in human anatomy."

Terms of description based upon the relation of an animal to the earth, *e.g.*, horizontal, vertical, longitudinal, etc., constitute an *extrinsic toponymy;* the *intrinsic toponymy* advocated and employed by the writers since 1880 includes only terms referring to the *regions of the organism, e.g., dorsal, mesal, caudal, ventrad*, etc.

§ 84. *Afferent* and *Efferent.*—Fr., afferent, efferent; Ger., afferent and efferent. These words, as applied to the nervous system, indicate the supposed direction taken by the nervous impulse; an afferent nerve conveys impulses toward the nervous centre, it is, therefore, equivalent to a sensory or a centripetal nerve, and it is said to extend *centrad.* An efferent nerve is one conveying impulses from the central nervous system. It is therefore equivalent to a centrifugal, motor, or secretory nerve, and the nerve is said to extend *peripherad.*

As applied to the lymphatic vessels, *afferent* indicates a vessel approaching a lymphatic gland, and *efferent* one leaving a lymphatic gland; both vessels extend centrad. (See article Lymphatic System, Vol. VIII., and under *central* and *peripheral.*)

Applied to blood-vessels, *afferent* indicates an artery, that is, a vessel extending peripherad to an organ, while *efferent* indicates a vein, that is, a vessel leaving an organ and extending centrad. (Klein, "Elements of Histology," p. 92.)

§ 85. *Caudal*, see under *Cephalic* and Fig. 5086, A.

Central and *peripheral* (adj.).

Central (adj.), centrad (adv.); Lat., centralis; Fr., central; Ger., central, centralwärts. Syn.: Centric, cardiac, proximal, afferent, centrally, centralward, heartward.

Peripheral (adj.), peripherad (adv.); Fr., périphérique; Ger., peripherisch, peripheralwärts. Syn.: peripheric.

Central and *centrad* designate position in, or direction toward, a central organ or system; while *peripheral* and *peripherad* designate position or direction away from the central organ or system.

Remarks: These terms are used occasionally in anatomy in their geometrical sense, referring for example to the centre or periphery of the eye; but in their proper technical sense they refer to the brain and myel (central nervous system or neuraxis), and the nerves (peripheral nervous system), or to the heart (centre of the vascular system) and the blood-vessels or lymphatics (peripheral part of the vascular system). In their purely anatomical sense these words apply to actual nearness or remoteness from the centre, as when it is said that a nerve, as the vagus, is cut and the central end stimulated, the end next the central nervous system or still in connection with it is intended, while the peripheral end is the one separated from the central nervous system, but in connection with the heart, lungs, etc. So also, in speaking of incisions in blood-vessels or lymphatics, the central side of the incision in either artery or vein is that nearest to the heart, while the peripheral side of the cut is away from the heart. Used in a physiological sense, the words indicate the direction taken by the contents of a vessel, as the veins extend centrad, the arteries peripherad; or the direction of the impulse of a nerve, the sensory nerves extend centrad and the motor nerves peripherad.

Equivalents. *Cardiac* is sometimes used for central (Allen). *Proximal* and *distal* are also used instead of central and peripheral (Chapman, 309; Foster, 222; Landois and Stirling, 117, 163). *Afferent* is equivalent to central, and *efferent* to peripheral. As used with the lymphatic vessels, both the afferent and efferent vessels of a gland extend centrad (see article Lymphatics, REFERENCE HANDBOOK, Vol. VIII.). *Above* is also used for central, and *below* for peripheral, in speaking of the valves in the veins and lymphatics (Gegenbaur (1883), 84; REFERENCE HANDBOOK, I., 591); with reference to the teeth, *central* is used to designate those next the meson, as the central incisors (REFERENCE HANDBOOK, VI., 741). Cf. remarks under *proximal* and *distal.*

§ 86. *Cephalic* and *Caudal.*—Cephalic (adj.); cephalad (adv.). Lat., cephalicus; Fr., céphalique; Ger., cephalwärts. Syn. of adverbial form: Cephalically, cephalward, headward.

Caudal (adj.), caudad (adv.). Lat., caudalis; Fr., caudal; Ger., caudalwärts. Syn. of the adverbial form: Caudally, caudalward, tailward.

Cephalic and *cephalad* are used to designate position in, or direction toward, the head end of the body. *Caudal* and *caudad* are used to designate position in, or direction toward, the tail end of the body (Fig. 5086, A). *Cephalic* and *caudal* are used with reference to the two extremities or ends of the body in exactly the same way that *right* and *left* (*dextral* and *sinistral*, with the adverbial forms) are used with reference to the sides of the body. (Comstock; W. and G.; Quain, i., 6, 128; Ranney, 35; Parker and Bellamy, 5, 16; REFERENCE HANDBOOK, I., 633; III., 1, 185, 193; VI., 209; VIII., 107–194; also in *Journal of Nervous and Mental Diseases*, in many articles; also in "Proceedings of the American Philosophical

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* The new edition of Leidy's "Human Anatomy," published after the completion of this article, represents a distinct and considerable advance over all other treatises in respect to nomenclature, particularly that of the brain. In the following extract from the preface the interpolated numbers refer to commentaries by the writer: "As a rule, one name for an organ or part is used,[1] and that one selected which is simplest and most expressive of its character.[2] The name, also, as far as may be permitted, is rendered into English.[3] Many phrases in common use as names[4] have been curtailed of what have appeared unnecessary portions,[5] and sometimes the adjective portion of the phrase has been retained, in preference to the substantive portion,[6] where, for various reasons, it has seemed more appropriate. Where names of persons are applied to parts, they are generally avoided,[7] and others, in all respects better adapted to the purpose, are used. Some further attempts have been made to improve the nomenclature,[8] and it is hoped that the experiment may prove successful in helping the student in acquiring a knowledge of the subject.[9] While the author regards with favor the proposed improvement in anatomical nomenclature of able authorities,[10] he has not followed them completely, in apprehension that, with the prevalent nomenclature, a radical change[11] would confuse rather than facilitate the study of anatomy." It will be seen that, to employ the more technical phraseology of the present article, (1) Pœcilonymy is avoided (§ 72); (2) in the choice between names, mere etymological appropriateness is subordinated to availability (§ 20); (3) the Latin words are commonly paronymized (§ 61) rather than translated into heteronyms (§ 62); (4) certain so-called names are rightly regarded as really descriptive phrases (§ 60), and (5) are reduced to mononyms (§ 25) when practicable; (6) when the adjective element of a polyonym is more distinctive than the substantive, the latter is dropped and the former used substantively; (7) eponyms are regarded as undesirable (§ 59); commonly the personal genitive or adjective is simply dropped, leaving, *e.g.*, *torcular* for *torcular Herophili*, *pons* for *pons Varolii;* but *sinus of Valsalva* is replaced by *valvular sinus;* (8) the other modifications consist mainly in converting polyonyms to mononyms by the substitution of prefixes for adjectives (§ 56); (9) Dr. Leidy has kept constantly in mind the needs of the student, who, in the effort to familiarize himself with the parts themselves, should be embarrassed as little as possible by their names; (10) he favors the eventual accomplishment of still further improvements, but draws the line now at new or unfamiliar terms, some of which, however, are given as synonyms, *e.g.*, *terma* for *lamina cinerea*, *porta* for *foramen Monroi*, *pseudocœle* for *fifth ventricle.* Notwithstanding these limitations, it may be said that in this latest treatise on human anatomy, by one alike eminent as an investigator, successful as a teacher, and conservative in his tendencies, there are embodied the more essential features of the system which is set forth in the organonymic division of the present article.

Society," and in the "Proceedings and Transactions of the Royal Society" (Gegenbaur, Fig. 106, pp. 115, 130).

As applied to the limbs, *cephalic* indicates the radial or thumb side of the arm, when the hand is semisupinated, *i.e.*, with the radius and ulna parallel, and the tibial or great toe side of the leg. *Caudal* refers to the ulnar or little finger side of the arm, the fibular or little toe side of the leg (Fig. 5086) (W. and G., 26).

Remarks.—*Cephalic* is frequently used to designate what pertains to the head, and *caudal* what pertains to the tail; as *caudal vertebræ*, that is, the vertebræ of the tail; as *cephalic skeleton*, the skeleton of the head or skull.

Equivalents.—*Cephalic* and *Cephalad* (H. A.) superior, superiorly, above, upper, upward; (C. A. and Emb.) anterior, anteriorly, front, forward, before, and as in man.

Caudal and caudad (H. A.).—Inferior, inferiorly, down, below, lower, downward; (C. A. and Emb.) posterior, posteriorly, behind, hinder, back, backward, and as in man.*

In the arms *cephalic* is outside and *caudal* inside; in the leg *cephalic* is inside and *caudal* outside, or cephalic is pre-axial and caudal post-axial in both arm and leg (W. and G., 25, 26).

§ 87. *Dextral and sinistral* (right and left).—Dextral (adj.), dextrad (adv.), sinistral (adj.), sinistrad (adv.). These terms or their vernacular equivalents are in use everywhere and have the same significance in human and comparative anatomy and in every day life. From the universality of the use of these terms and their ready comprehensibility by everybody they serve as models for the designation of the other four aspects of the body, as was clearly pointed out by Comstock ("Laboratory Guide to Entomology"). These terms are also used in a very comprehensive sense, as when in directing a person he is told to turn to the right or to the left; hence when an organ or part is said to face or extend cephalad or dorsad the meaning should be considered exactly as when it is said that a part faces or extends to the right or the left, that is, *a general direction should be understood and not some specific point on the body*. If the terms of direction and position are used in the general sense that *right* and *left* are, to indicate relative but not absolute position or direction, then the apparent absurdity of speaking of the cephalic end of the tail, vanishes.

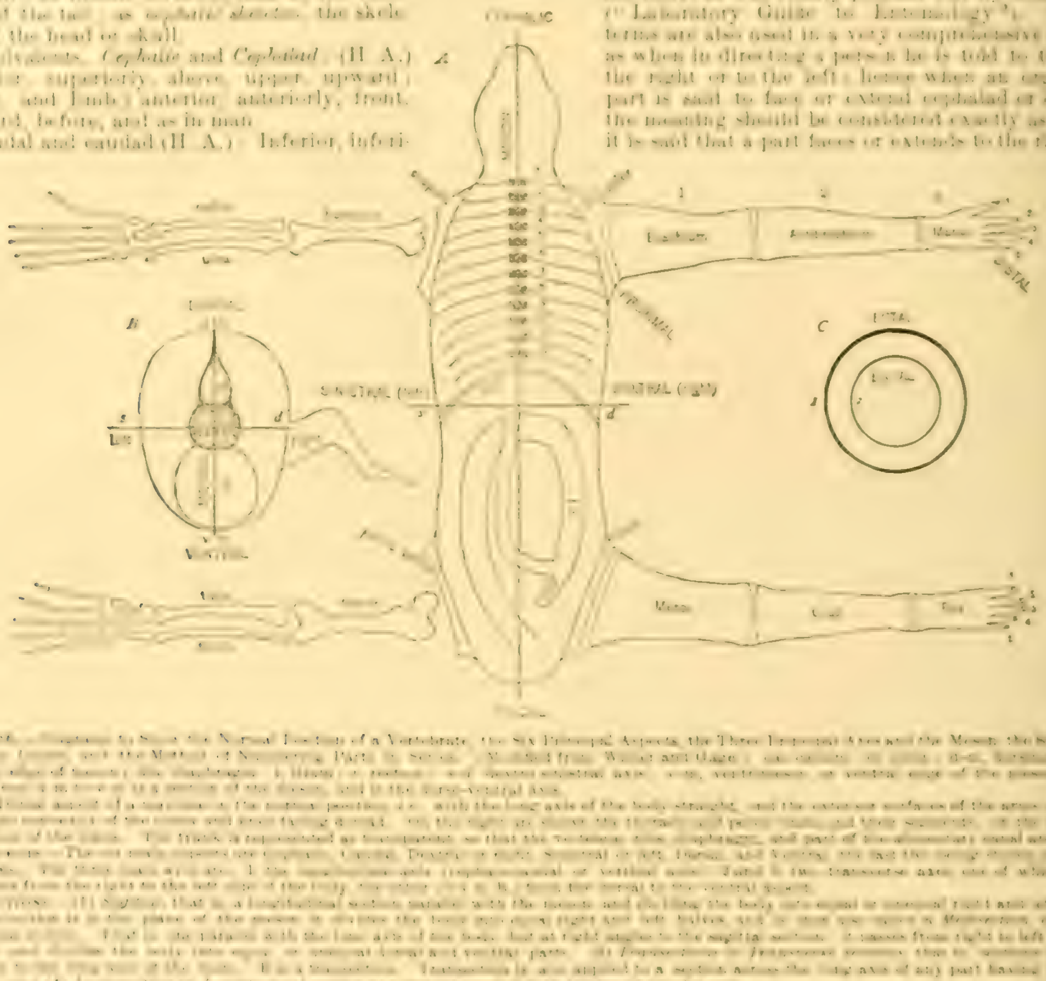

FIG. 5086.—Diagrams to Show the Normal Position of a Vertebrate, the Six Principal Aspects, the Three Principal Axes and the Meson, the Segments of the Trunk, and the Method of Numbering Parts in Series. (Modified from Wilder and Gage.) [illegible]

A. Dorsal aspect of a vertebrate in the normal position, *i.e.*, with the long axis of the body straight, and the extensor surfaces of the arms and legs [illegible]

Aspects.—The six main aspects are Cephalic, Caudal, Dextral or right, Sinistral or left, Dorsal, and Ventral [illegible]

[illegible]

B. [illegible]

C. Diagram to show the method of naming and numbering parts at different distances from the surface. [illegible]

Distal, see under Proximal and Fig. 5086, A.

Dorsimeson, the dorsal edge of the meson (Fig. 5086, B, d. m.); see also under Meson.

§ 88. *Dorsal and Ventral.*—Dorsal (adj.), dorsad (adv.), Lat., dorsalis; Fr., dorsal; Ger., dorsal, dorsalwärts. Syn., tergal, neurad, dorsally, dorsalward.

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* Whenever it is stated in this [illegible] (C. A. and Emb.) [illegible]

Ventral (adj.), ventrad (adv.); Lat., ventralis; Fr., ventral; Ger., ventral, ventralwärts; Syn., hæmal, hæmad, visceral, viscerad, ventrally, ventralward.

Dorsal and dorsad are used to indicate position in, or direction toward the back, that is the part containing the central nervous system (Fig. 5086, B), while ventral and ventrad are similarly used to designate position in or direction toward the belly side of the body, that is, the side containing the vascular and digestive systems (Fig. 5086, B, H). These terms should be used in the same general way as *right* and *left* (*q. v.*) are.

Reference Handbook, I., 634–635; III., 178–193; V., 774, 776; VI., 380, 592; VIII., 107–194; Barclay; W. and G.; Comstock; Owen (1868), i., 2, 473; Allen, 21, 201; Gray, 846; Parker, 48, 127; Bernard, 252; Quain, i., 3, 5, 129; ii., 318; Huxley and Martin, 31, 37; Howell, 7, 36, 35; Marshall and Hurst, 259; Parker, 222, 307; Morrell, 203; Rolleston and Jackson, 13; Gegenbaur (1883), 103, 114.

With the limbs, *dorsal* refers to the dorsum of the hand and foot and to the extensor side of both arm and leg; the convexity of the knee and the elbow point dorsad when they are in the normal position (Fig. 5086, A and B). *Ventral* refers to the palm and the sole, and to the flexor side of the arm and leg. In Fig. 5086, A, it is the surface not seen, in B it is the concavity of the elbow or knee.

Equivalents: Dorsal and dorsad; (H. A.) posterior, posteriorly, back, backward; (C. A. and Emb.) superior, superiorly, upper, upward, also as in man.

Ventral and ventrad; (H. A.) anterior, anteriorly, front, forward; (C. A. and Emb.) inferior, inferiorly, lower, down, downward, also as in human anatomy.

Remarks: Dorsal and ventral have some special uses, for example the ectal aspect of the human scapula and ilium is said to be dorsal, while the ental aspect is said to be ventral (Gegenbaur (1883), 261). Dorsal has retained its original and more specific use for designating the thoracic vertebræ, and for designating parts situated in what is considered a dorsum, as the dorsal artery of the penis; its use is, however, becoming generalized like right or left, and with the tongue, foot and hand the general and specific uses coincide. In the limbs, dorsal is the back of the arm, and the front of the leg, while ventral is the back of the leg and the front of the arm.*

§ 89. *Ectal and Ental.*—Ectal (adj.), ectad (adv.). Greek, ἐκτός; Lat., ectalis; Fr., ectal; Ger., ec- or ektal, ectalwärts; Syn., of the adverbial form ectally, ectalward. Ental (adj.), entad (adv.); Greek, ἐντός; Lat., entalis; Fr., ental; Ger., ental, entalwärts; Syn., entally, entalward. *Ectal* and *ectad* indicate position on or direction toward an aspect or surface farther from an actual or supposed centre than some other part with which it is compared (Fig. 5086, C). *Ental* and *entad* indicate a position or direction comparatively nearer a real or supposed centre, or farther from the periphery than the ectal or starting-point (Fig. 5086, C), as the ectal or free surface of the skin, the ental or subcutaneous or attached surface, the ectal or subcutaneous surface of a rib, the ental or pleural surface of the same (Wilder, "Science," vol. ii. (1881), pp. 122–22, 126, 133–138; W. and G., 26–27; Reference Handbook, VIII., 107–194).

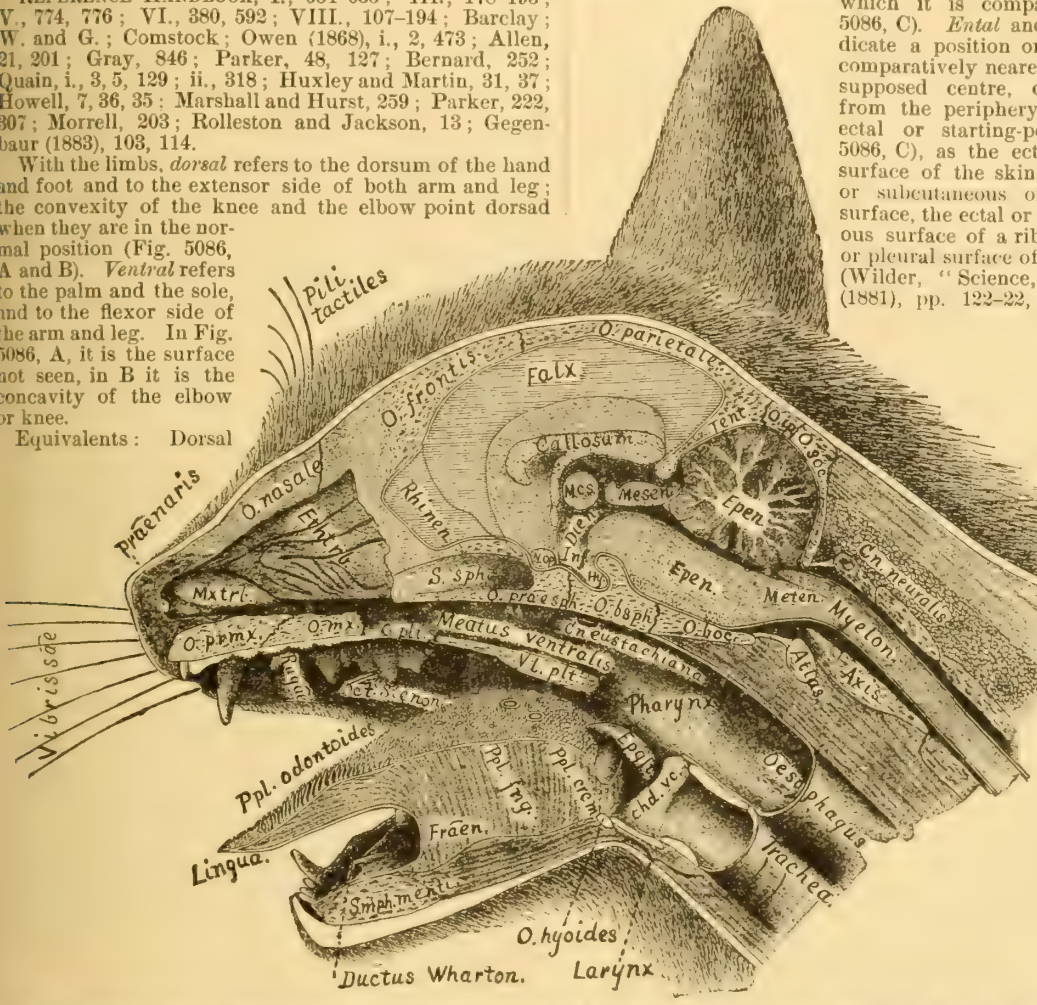

Fig. 5087.—Mesal Aspect of the Right Half of a Cat's Head for Comparison with a Similar View of a Human Head (Fig. 4684). (Wilder and Gage.) This figure is introduced to show that in many of the lower animals the mouth and nose are nearly in line with the body axis, while in man (Fig. 4684) they are nearly at right angles to the body axis. From this it results that in the head, the terms front, back, anterior, posterior, upper, and lower as used in human and comparative anatomy, agree in significance, although in the rest of the body the terms indicate position and direction differing by ninety degrees.

Remarks: These terms were introduced by Wilder in 1881, to take the place of outer, inner, external, internal, superficial, and profound. They conform readily to paronymyzation, definiteness, and general applicability to human and comparative anatomy. Note the recent embryological term, *ectental line*.

Equivalents: External, internal; outer, inner; superficial and profound, or deep.

Ental, see under *ectal*, and Fig. 5086, C.

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* Ventral is commonly applied to the fins of fishes representing the legs, but *pelvic* would be less ambiguous and better correlated with *pectoral*.

Lateral, see under *mesal*; also Fig. 5086, A and B.

§ 90. *Mesal* and *Lateral*.—Mesal (adj.), mesad (adv.); Lat. mesalis; Fr. mésal; Ger. mesal, mesalwärts, medianwärts; Syn., mesally, mesalward, mesial, mesiad, medial, mesialward, medius, medial—position at or direction toward the meson (Fig. 5086, A and B). Lateral (adj.), laterad (adv.); Lat. lateralis; Fr. latéral; Ger. lateral, seitenwärts—position or direction away from the meson on either side of the body.

Allen, 20; Barclay; Comstock; Darling and Ranney, 10, 21; Gegenbaur (1878), 41; Gray, 145, 848; Henle, I., 10; Krause, ii., 2; Parker and Bellamy, 3, 5, 16, 230, 254; Quain, i., 3; ii., 339, 910; Reference Handbook, I., 258, 638; VIII., 107, 194; Rolleston and Jackson, 14; Sappey, i., 64; W. and G.; Parker, "Proceedings Royal Society," vol. xlix., p. 395; Stowell, "Proceedings American Philosophical Society," 1881, 1886, 1888.

Remarks: Mesal and lateral are both general terms, as there are two sides to the body and correspondingly two faces to the meson. The terms indicate position and direction applicable to both symmetrical halves. For example, if a structure is said to extend mesad, it would not be known whether it was extending from the right side of the body toward the meson, or from the left side; so with lateral. It simply means toward the right or toward the left. Usually the context gives the specific information. In some cases it is desirable to use dextral or sinistral instead of lateral in order to be perfectly definite.

These terms are not properly applicable to the limbs, for when the limbs are in the normal position, *i.e.*, a position in which homologous parts may be readily compared in man and animals, and also in the arms and legs, the mesal aspect is proximal and the lateral aspect distal (see Fig. 5086). As used in both human and comparative anatomy, the median aspect of a limb is the one in the natural position of the limb which faces mesad and the lateral aspect the one facing laterad. From this it follows that the ulnar side is median, or inner, with the arm, and the radial side lateral, or outer, while in the leg the tibial side is median or inner and the fibular side lateral or outer.

Equivalents: Mesal, internal, internally, inward, inner. Lateral, external, externally, outer, outward.

§ 91. *Meson*.—Synonyms and equivalents: Mesian (Barclay, 121); mesial plane (Quain, i., 5); median plane (Darling and Ranney, 17); median vertical plane or vertical median plane (Huxley (1873), 30; Gegenbaur (1878), 416). Fr., plan médian (Morel and Duval, 37); plan vertical antero-postérieur, plan médian (Sappey, i., 13). Ger., medianebene (Henle, i., 7; Hoffmann, i., 5); mittelebene (Krause, ii., 2). Besides these proper terms, mesial, middle or median line, is often used for the meson or median plane (Flower, 72, 10; Foster and Langley, 2; Gegenbaur (1878), 442; Gegenbaur (1883), 7; Huxley and Martin, 8; Reference Handbook, II., 179, 305; III., 172; V., 538; VI., 632; Rolleston and Jackson, 3). The meson, mesal or median plane is an imaginary longitudinal plane extending from the dorsal surface of the body to the ventral surface and dividing the body into right and left symmetrical halves (Fig. 5086). The term meson was introduced into anatomical literature by Wilder (Science, ii., 1881; W. and G., 25).

Ventrimeson and *Dorsimeson*.—These terms indicate the ventral and the dorsal edges of the meson (Fig. 5086, B, v m, d m).

Equivalents: Dorsal and ventral mid-line (Howell, 15, 30); dorsal and ventral middle line (Huxley and Martin, 41); mid-dorsal and mid-ventral line (Parker, 99, 115); median dorsal or ventral line (Reference Handbook, III., 177; V., 248). Fr., ligne médiane du ventre, du dos (Milne-Edwards, iv., 474, 476); ligne médiane postérieure et antérieure (Sappey, i., 13). Ger., Medianlinie der ventralseite, der dorsalseite (Claus, "Zoologie," 633).

Ventrimesal, ventrimesad, dorsimesal, dorsimesad.—These terms indicate direction or position in or toward the edge of the meson indicated by first part of the word (W. and G., 25).

Peripheral, see under *Central*.

§ 92. *Proximal* and *Distal*.—Proximal (adj.), proximad (adv.); Fr. proximal; Ger. proximalwärts.

Distal (adj.), distad (adv.); Fr. distal; Ger., distal, distalwärts.

Proximal indicates position at or direction toward the attached extremity of an appendage, or at some point nearer the attached extremity than some other point with which it is compared. For example, the shoulder is proximal of the elbow, but the elbow is proximal of the wrist, etc. (Fig. 5086, A). The free extremity of the organ is often called the distal when the attached end is the proximal end. Where an object is attached at both ends the more important is usually called proximal, as the vertebral attachment of a rib is called the proximal and the sternal attachment distal.

Distal and *distad* indicate direction or position in a part or appendage away from the attached or proximal end.

Barclay, 124; Ranney; Darling and Ranney, 141; Flower, 241; Gray, 1, 278; Gegenbaur (1883), 175, 287; Huxley, 19, 29, 31; Morel, 29; Owen (1868), i., 408; Quain, i., 6; ii., 863; Parker, 101, 104, 53; Parker and Bellamy, 277; Reference Handbook, I., 310; II., 827; III., 188, 209, 486; VI., 596; W. & G.

Remarks: As stated under central and peripheral, proximal is sometimes used for central and distal for peripheral.

Right, see under *Dextral*.

Sinistral, see under *Dextral*; also Fig. 5086.

Ventral, see under *Dorsal*; also Fig. 5086, B.

Ventrimeson, *Ventrimesal*, *Ventrimesad*, see under *Meson*, and Fig. 5086, B.

§ 93. In using these terms for the designation of position, or of lines, or for the indication of direct and oblique lines they may be employed as are the more common expressions, for example, the scapula of man is at the dorsal and the cephalic (upper and back) part of the thorax. A line drawn from the xiphisternum to the kidney would extend dorsad, caudad, and laterad (backward, downward, and outward). These terms may also be combined as are the words designating the points of the compass, and instead of saying the cephalic and the dorsal, the two words are combined thus, cephalodorsal; and so in the second example the line extending from the xiphisternum to the kidney is a dorso-caudo-lateral line or it extends dorso-caudo-laterad, etc.

§ 94. Numbering the Parts of a Series.—The general rule is to commence with the most cephalic, *e.g.*, the first rib is the most cephalic (Fig. 5086); 2, the most proximal is first, as the first segment of the thoracic limb is the brachium (Fig. 5086); 3, the most distal of a number of layers is first, as the first layer of muscles is next the skin; with the germinal layers the ectoderm is first. With blood vessels and nerves there is a tendency to number from the origin so that the first part of the aorta is the most central, that is the arch, but the first part of the postcava is that formed by the two iliac veins, etc.

In the limbs the most proximal of a series is first, as the first row of carpals is next the radius and ulna, but in numbering the individual elements the first is the most preaxial or cephalic, that is the scaphoid.

In numbering the fingers and toes, the thumb and great toe are first; they are most cephalic if in a natural position (Fig. 5086).

In numbering the teeth the one nearest the meson, *i.e.*, the symphysis, is number one; this is also said to be the proximal one while the last molar is the distal one (Gray, 841; Quain, ii., 847; Reference Handbook, VI., article Teeth).*

The above rules are almost universally adhered to and deviation is due rather to lack of knowledge than to design.

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THIGH. APPLIED ANATOMY.—The thigh comprises a section of the lower extremity, bounded above and posteriorly by the gluteo-femoral crease, laterally and in front, by an imaginary continuation of this line around the circumference of the limb.

The artificial antero-lateral upper limit of the anatomical thigh is placed 12 to 15 ctm. below Poupart's ligament. Above the thigh are, behind and externally, the gluteal region and hip, in front, the subinguinal region.

Internally, the converging lines of Poupart's ligament and the upper limit of the thigh meet at the outer margin of the perineal and ischio-rectal spaces.

The lower limit of the thigh is formed by the upper boundary of the next adjoining regions, namely, the *popliteal space* behind and the *knee* in front. The capsular ligament of the knee-joint in the extended position of the thigh reaches from 3 to 8 ctm. above the upper border of the patella, and forms the lower boundary of the thigh at this point.

The general shape of the thigh is that of a cone. A grooved depression or furrow extends along the inner aspect of the limb, beginning above in the subinguinal region, and corresponding to the interval between the adductor group and the vastus internus. Along this depression course the large vessels of the lower extremity, and incisions for ligature of the femoral artery are made in this situation.

An external depression, extending nearly vertically on the outer aspect of the thigh, and more pronounced in thin subjects, marks the interval between the vastus externus and the biceps, and corresponds to the external intermuscular septum of the deep fascia (see Fascia lata, p. 538). This lateral groove serves to divide the thigh on its surface into an anterior and a posterior segment. Internally the dividing line is not so well marked. The prominence formed by the adductor gracilis muscle may be taken as such; but for practical purposes it is more desirable to include in the anterior division the entire adductor group, on account of their intimate relation to important vessels and nerves which belong to the anterior part of the thigh.

A. ANTERIOR REGION OF THIGH.—*Integument and Superficial Fascia.*—The integument of the anterior region is firm and dense, extremely retractile on transverse division, and easily separated from the deep fascia. In circular amputation of the thigh, these anatomical characteristics are of considerable aid, enabling the operator to dispense with a specially prepared and reflected cylinder of integument.

The subcutaneous areolar tissue and fat form a layer of varying thickness, usually much more developed in the female. It forms a continuous investment for the whole of the lower extremity, and can usually be divided into two or more layers, between which are situated the superficial vessels and nerves, and in the inguinal region the superficial inguinal lymphatic glands. The superficial layer is continuous above with the superficial layer of the abdominal fascia; the deep layer of the abdominal fascia becoming adherent to the fascia lata of the thigh, about three ctm. below Poupart's ligament.

Superficial Veins.—The most important is the v. saphena magna—the great or internal saphenous vein with its tributaries. This vein, ascending from the foot and leg, passes behind the internal condyle of the femur, and then along the median aspect of the thigh, corresponding pretty accurately in direction to the inner border of the sartorius muscle—close behind which it is situated,—to open into the femoral vein through the saphenous opening of the fascia lata, about one and a half inch below Poupart's ligament. A second large cutaneous vein, draining the antero-lateral regions of the thigh, joins the v. saphena magna near its termination. The veins from the inner and back part of the thigh either open into the same vessel singly, as a number of smaller branches, or unite to form a third large subcutaneous vein, which joins the saphena magna near the falciform opening. The veins corresponding to the superficial branches of the femoral artery, viz., the vv. pudendæ externæ, epigastrica superficialis, circumflexa ilii superficialis, open either into the v. saphena magna near the saphenous opening, or pass through this opening to terminate in the v. cruralis.

At times the superficial dorsal veins of the penis empty all, or in part, into the saphena instead of into the deep dorsal vein of the penis.

Frequently the saphena is double; the two trunks uniting near the saphenous opening to form a common vessel which receives the tributaries above mentioned.

As the vein usually runs somewhat behind the inner margin of the sartorius, it is readily avoided in operations for ligature of the femoral artery. If exposed by the first incision, which should simply divide the integument, the vein can be drawn to the inner side.

The *superficial lymphatic vessels* for the most part course along the inner aspect of the thigh with the saphena magna. A few run along the posterior and external aspect. All empty into the superficial inguinal glands (gl. crurales).

The superficial nerves are derived from the lumbar plexus.

1. *Ilio-inguinal*, derived from first lumbar nerve, after emerging from the external abdominal ring, or perforating the external pillar of the ring, arrives at the outer side of the spermatic cord, where it divides into its terminal branches. The more numerous (internal or transverse) branches pass to the hypogastric region. The external or descending branch is distributed to the integument of the inner inguinal region, and the upper and inner aspect of the thigh. Those thigh branches of the ilio-inguinal can be replaced by the genital branch of the genito-crural (n. spermaticus externus), which communicates with the ilio-inguinal at the external abdominal ring.

2. The external or crural branch of the *genito-crural nerve* (n. lumbo-inguinalis) is derived from the second lumbar nerve, and passes beneath Poupart's ligament to the outer side of the femoral vessels to be distributed to the integument of the anterior aspect of the thigh. A few branches become cutaneous by passing through the saphenous opening to the outer side of the saphena vein. Others perforate the fascia lata external to the saphenous opening. Their distribution is somewhat variable, as branches from the external cutaneous nerve, and cutaneous branches from the anterior crural (especially the middle cutaneous) can replace them. Usually they do not extend beyond the middle of the anterior aspect of the thigh.

3. *The external cutaneous nerve* (n. cutaneus femoris lateralis) is derived from the second loop of the lumbar plexus, receiving filaments from the second and third lumbar nerves. It passes below and in front of the anterior superior iliac spine to the thigh, lying in front of the deep circumflex iliac artery beneath Poupart's ligament, and then in front of the tendinous origin of the sartorius muscle. In the thigh the nerve lies in a canal in the fascia lata, and divides into an anterior or descending main branch, and a posterior branch, which perforate the fascia separately to become cutaneous.

a. The *posterior branch* (ramus glutaeus) passes obliquely over the tensor vaginae femoris to the integument of the posterior part of the thigh and of the lower gluteal region.

b. The *anterior branch* (ramus femoralis) is the direct continuation of the main nerve. Perforating the fascia lata 3 to 5 cm. below Poupart's ligament, the nerve becomes cutaneous and passes along the anterior surface of the vastus externus to the outer aspect of the knee. Lateral branches variable in number and size are given off, especially on the outer side. They pass obliquely outward and backward.

At times (according to Schmidt twice in thirty-three subjects) the external cutaneous nerve at first runs with the anterior crural, and, either beneath or below Poupart's ligament, turns suddenly outward to its proper distribution. The nerve can either completely replace the crural branch of the genito-crural nerve, or send branches to reinforce the peripheral distribution of the same.

4. Branches from the distribution of the *anterior crural nerve*, which arises by three branches from the second, third, and fourth lumbar nerves, and probably receives fibres from the first lumbar nerve through the first lumbar ansa. The nerve passes into the thigh through the lacuna musculorum beneath Poupart's ligament, between the psoas and iliacus muscles, and separated from the femoral artery, which lies to the inner side, by the former muscle. In the thigh the nerve divides into an anterior, chiefly sensory, and a posterior, chiefly muscular, division.

An *anterior division* gives cutaneous branches to the anterior and inner aspects of the thigh, and a muscular branch to the sartorius.

a. *The middle cutaneous nerve* (n. cutaneus femoris anterior medius) is usually composed of two branches.

(1.) *The superior branch* (ramus perforans superior) is a musculo-cutaneous nerve, supplying the sartorius muscle, along the posterior aspect of which it passes. The continuation of the main nerve usually perforates the sartorius at the junction of the upper and middle thirds, and piercing the fascia lata immediately, passes as a cutaneous nerve along the anterior surface of the thigh as far as the knee.

(2.) *The inferior branch* (ramus perforans inferior) at times is given off from a common trunk with the preceding, but is usually a separate branch from the anterior terminal division of the anterior crural. Usually it does not supply branches to the sartorius. It perforates the fascia lata to the inner side and below the preceding nerve, and passes downward as far as the knee, supplying the integument of the anterior region of the thigh.

b. *The internal cutaneous nerve* (n. cutaneus femoris medialis) usually consists of two, sometimes of three, branches. One perforates the fascia lata below the saphenous opening and runs along the saphena vein to below the middle of the thigh. This branch frequently communicates with a cutaneous branch from the obturator nerves. The second branch (sometimes double) runs down along the median margin of the sartorius, perforating the fascia a short distance above the patella to supply the integument on the inner aspect of the knee.

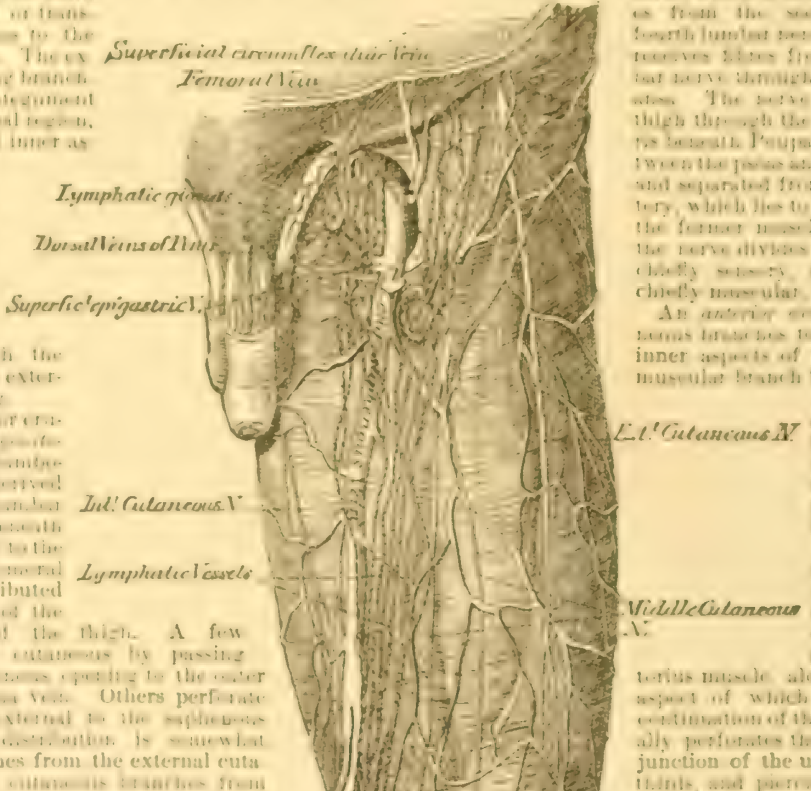

FIG. [illegible].—Superficial Veins, Nerves, and Lymphatics of Front of Thigh. (Allen.)

The fascia lata envelops the entire thigh, forming a continuous investment for the deeper structures. A division into an anterior and posterior part is therefore impracticable. The fascia is attached above and in front to Poupart's ligament, and to the body and horizontal ramus of the pubes; externally to the outer limb of the crest of the ilium, posteriorly to the sacrum and coccyx; internally to the descending ramus of the pubes, ascending ramus, and tuberosity of the ischium, joining with the lower border of the great sacro-sciatic ligament. For the formation of the saphenous opening and the relation of the fascia lata to the sheath of the femoral vessels, the reader is referred to the article on hernia and the topographical anatomy of the subinguinal region.

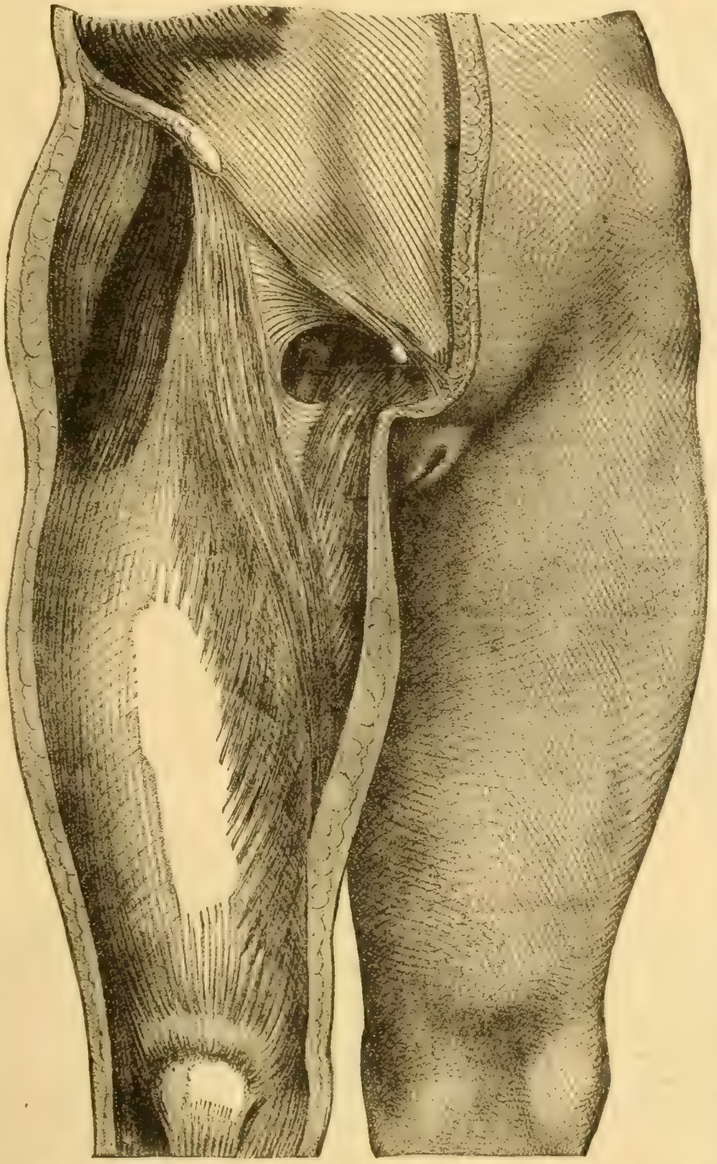
Fig. 5089.—Antero-external View of Thigh, showing Fascia Lata and Tensor Vaginæ Femoris. (Henke.)

Posteriorly this fascia covers in, above, the glutæus maximus muscle, forming a thin layer closely united to the inter-fascicular connective-tissue septa of the muscle, and composed of fibres which run nearly at right angles to the course of the muscular fasciculi. A thin layer of the fascia passes beneath the glutæus maximus, separating it from the glutæus medius, and becoming continuous with a very dense fascia which forms a firm investment for the anterior free portion of the latter muscle. The strongest portion of the fascia lata is situated at the upper and outer part of the thigh. Here it is composed of two layers of fibres which cross each other at right angles, a superficial vertical and a deep circular set. This external portion of the fascia is considerably reinforced by a fibrous expansion which passes to it from the superficial portion of the tendon of the glutæus maximus. In this situation also the tensor vaginæ femoris is inserted between its layers. Posteriorly, and at the upper and inner part, where it covers in the adductor group of muscles, the fascia is very thin. Around the knee it is strengthened by fibrous expansions from the tendon of the biceps externally, and from the sartorius, gracilis, semi-tendinosus, and quadriceps extensor cruris internally and in front. Below, the fascia lata is attached to the condyles of the femur, tuberosities of the tibia, and the head of the fibula.

The fascia surrounds all the muscles of the thigh, exerting considerable pressure on the same, so that after division of the fascia a hernia-like protrusion of the muscle takes place. Between fascia and muscle is a layer of thin cellular tissue, in which suppurative and phlegmonous processes readily become diffused.

The portion of the fascia lata arising from the forepart of the crest of the ilium, corresponding to the origin of the tensor vaginæ femoris, passes down as two layers, which include the muscle between them, and at its lower border blend together after having received the insertion of the muscle, forming a firm, dense band. This band passes down to become attached to the outer tuberosity of the tibia, and is known as the *ilio-tibial* or *Maissiat's band*. According to Maissiat, this band helps to limit adduction of the thigh.

The fascia lata sends inward from its deep surface a number of intermuscular septa, which form compartments in which the muscles of the thigh are lodged. Two of these are of especial strength, and pass inward to be inserted into the linea aspera of the femur. They are called the *external* and *internal intermuscular septa* (Lig. intermuscularia laterale et mediale). Together they limit a space in which are found the adductors of the thigh and flexors of the leg.

The external intermuscular septum arises from the entire extent of the outer lip of the linea aspera, from the trochanter major to the external condyle of the femur. It separates the vastus externus from the glutæus maximus above, and from the short head of the biceps below. It is well shown at its upper part, between the vastus externus and glutæus maximus, in Fig. 5090, which represents a transverse section at right angles to the long axis of the thigh, immediately below the lesser trochanter of the femur.

It is possible to penetrate deeply into the thigh along the external intermuscular septum, as far as the femur, without dividing any important muscles, vessels, or nerves—a fact which is of considerable importance in operations, such as sequestrotomy, or the opening of subperiosteal abscesses, etc.

The internal intermuscular septum follows the inner lip of the linea aspera, to which it is firmly attached. It arises above from the lesser trochanter, and follows

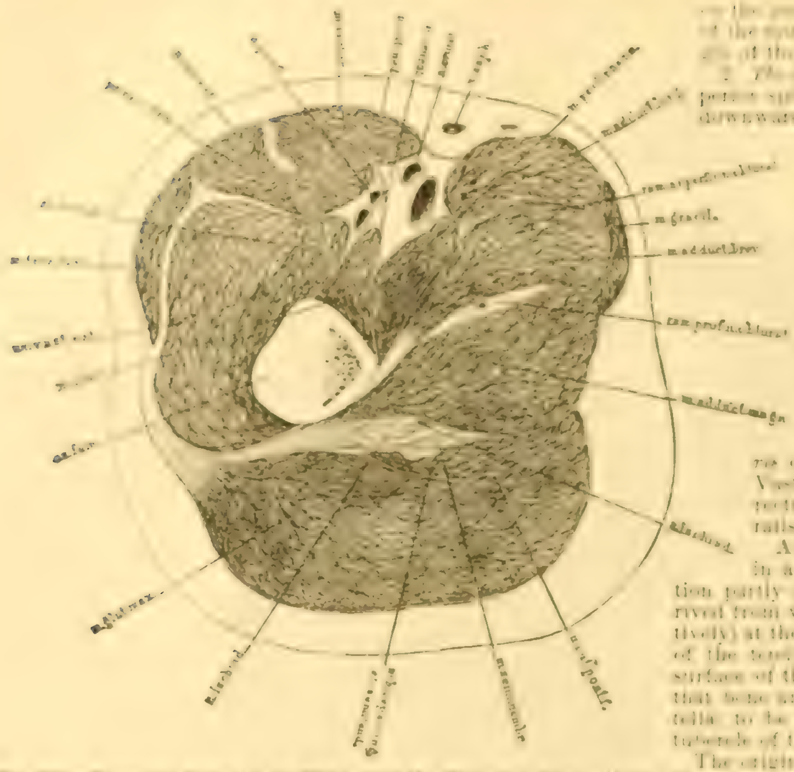

Fig. [illegible].—Transverse Section of the Thigh, below the Trochanter Minor. (After Braune.) [illegible]

on the preceding page. The posterior margin of the muscle touches above the internal margin of the gluteus medius.

2. *The sartorius* arises from the anterior superior spine of the ilium, and passes obliquely downward and inward behind the internal condyle of the femur, turning forward again, to be inserted into the inner aspect of the tibia.

Between the sartorius, adductor longus, and Poupart's ligament is situated Scarpa's triangle, or the trigonum subinguinale, in which the femoral artery and vein and the branches of the anterior crural nerve are placed. The sartorius at its upper part lies to the outer side of the femoral vessels, crosses them at the apex of Scarpa's triangle, and lies to their inner side below.

3. *The extensor quadriceps femoris* consists of four portions or heads: *a*, Vastus externus; *b*, vastus internus; *c*, rectus femoris; *d*, vastus medius or cruralis.

All four of these muscular bellies join in a common tendon, which finds insertion partly at the base, partly (the portions derived from vastus internus and externus, respectively) at the margins of the patella. A portion of the tendinous fibres passes over the anterior surface of the patella, and at the lower border of that bone unites with the strong ligamentum patellæ to be inserted into the lower part of the tubercle of the tibia.

The origin of the different portions of the quadriceps extensor is as follows:

a. The Rectus Femoris.—The median and superficial portion arises by two heads: One, the straight head, arises from the anterior inferior spinous process of the ilium; the other, called the reflected head, arises from a depression just above the acetabulum.

the origin of the vastus internus, becoming lost below in the tendinous portion of the adductor magnus.

A third important fascial layer separates the muscles situated on the posterior aspect of the thigh from the adductor group. As is well shown in the accompanying plates, this layer appears in transverse sections as a somewhat thinner fascial structure, which joins the external intermuscular septum at its insertion into the linea aspera.

The three layers just described divide the muscles of the thigh into three main groups, viz.: 1, An anterior group, comprising the tensor vaginæ femoris, sartorius, and quadriceps extensor femoris; 2, an inner group, comprising the adductors; and 3, a posterior group, comprising the biceps, semitendinosus, and semimembranosus.

A glance at Fig. [illegible] shows that the femoral vessels course between the anterior and internal of these groups, viz., between the vastus internus and the adductors.

I. MUSCLES OF THE ANTERIOR GROUP.—1. *Tensor vaginæ femoris* arises from the crest of the ilium, close to the anterior superior spine, and is inserted into the so-called "band" of Maissiat, already described

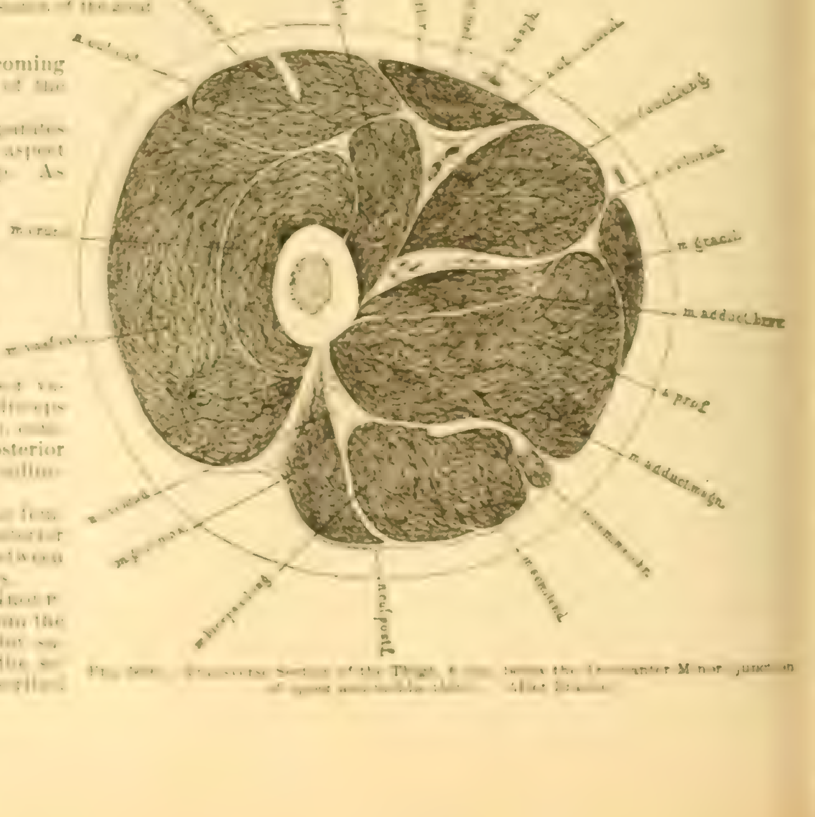

Fig. [illegible].—Transverse Section of the Thigh, 4 cm. below the Trochanter Minor; junction of upper and middle thirds. (After Braune.)

b. The vastus internus arises along the whole length of the inner lip of the linea aspera, and from the anterior and lateral surfaces of the femur. This deeper portion is at times completely separable from the vastus externus, as well as from the main portion of the vastus internus, and has, therefore, been designated by the name of vastus medius, or m. crureus s. cruralis. Usually, however, this part of the muscle is intimately blended with the vastus externus and internus, especially with the latter muscle. In Fig. 5091, representing a transverse section of the thigh just below the junction of the upper and middle thirds, the fascial septum, which at times separates the crureus from the vastus internus as well as from the vastus externus, is very perfectly shown.

c. The vastus externus arises from the whole of the external labium of the linea aspera, beginning above at the base of the trochanter major, immediately beneath the insertion of the glutæus medius and glutæus minimus. Some fibres also arise from the external intermuscular septum.

At about the middle of the thigh the vastus externus and vastus internus become united with each other, and at the beginning of the lower third the superficial and anterior fibres of these muscles join the outer and inner margin, respectively, of the tendon of the rectus femoris, which is inserted into the upper border of the patella, the superficial fibres passing across the anterior surface of the bone as a dense aponeurotic layer which joins the ligamentum patellæ. The remainder of the fibres of the vastus externus and internus terminate by a tendinous insertion into the outer and inner borders of the patella.

Beneath the crureus is found a small muscular slip, which arises from the anterior surface of the lower fourth of the shaft of the femur, and is inserted into the upper pouch of the knee-joint which passes upward beneath the extensor. It is called the *subcruralis*.

II. MUSCLES OF THE INNER OR ADDUCTOR GROUP. — 1. *Gracilis.*—A long, slender muscle arising from the descending ramus of the pubes, close to the lateral margin of the symphysis, and inserted together with the sartorius and semitendinosus into the inner surface of the tibia.

2. *The pectineus* arises from the ilio-pectineal line and surface of the pubes in front of it, between the ilio-pectineal eminence and spine of the pubes, and is inserted into a rough line passing downward from the lesser trochanter, between the outer and inner lips of the linea aspera.

Between the pectineus and ilio-psoas muscles is a deep furrow or depression, the fossa ilio-pectinea, which forms part of the floor of Scarpa's triangle, and in which are contained the femoral vessels.

3. *The adductor longus* arises by a narrow tendon from the space between the symphysis and spine of the pubes, and is inserted into the middle third of the inner lip of the linea aspera.

4. *The adductor brevis* is covered in by the adductor longus and pectineus. The muscle arises from the descending ramus of the pubes at its junction with the body beneath the adductor longus, and between the origin of that muscle and the margin of the obturator foramen, and is inserted into the upper third of the interspace of the linea aspera, somewhat above the insertion of the adductor longus.

5. *The adductor magnus* arises from the tuber ischii and the ascending ramus of the ischium. The portion arising from the ramus forms a deep layer, which finds insertion along the whole length of the linea aspera, behind the adductor longus.

The superficial portion of the muscle arising from the tuberosity of the ischium, forms the inner margin of the muscle, and terminates in a rounded tendon which is inserted into the adductor tubercle, or internal epicondyle of the femur.

In the lower third of the thigh tendinous fibres pass from this superficial portion of the adductor magnus obliquely to the vastus internus. In this way a canal (*Hunter's canal*) is formed, about five ctm. long, in which are contained the femoral vessels and the internal saphenous nerve. The anterior wall of this canal is formed by the above-mentioned oblique tendinous fibres passing from the adductor magnus to the vastus internus. The vastus internus also forms the external wall, while the posterior wall is formed by the adductor longus, which lies upon the deep muscular portion of the adductor magnus, and is intimately connected with it.

The upper opening of Hunter's canal is bounded by a crescentic tendinous fold of the adductor magnus. The lower opening is situated in the deep portion of the muscle close to its insertion, and is also surrounded by tendinous fibres. Through this so-called "adductor foramen" the femoral vessels pass into the popliteal space.

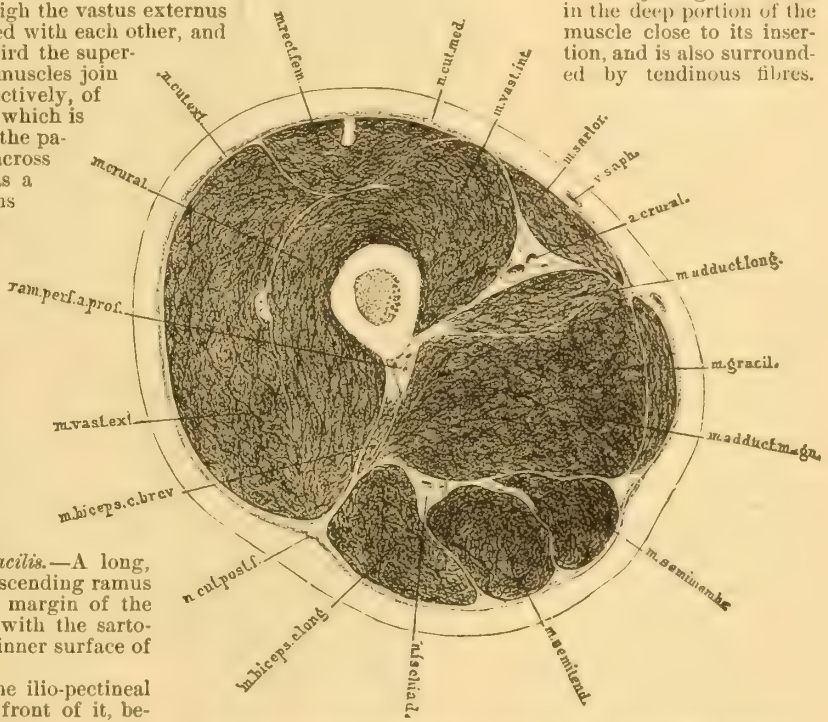

FIG. 5092.—Transverse Section of Thigh about the Middle. (After Braune.)

6. *Adductor minimus.*—Under this name a muscular bundle is known which is regarded by many authors as the uppermost portion of the adductor magnus. It arises from the ascending ramus of the ischium and descending ramus of the pubes, external to the origin of the gracilis, and is inserted into a line which descends vertically from the middle of the posterior intertrochanteric line to the linea aspera. Above this muscular bundle is the quadratus femoris; below, it overlaps the upper margin of the adductor magnus from behind. A large branch of the internal circumflex artery passes between the adductor minimus and quadratus femoris. Between the adductor minimus and adductor magnus the first perforating artery from the profunda usually passes.

The *femoral* or *crural artery* begins at Poupart's ligament and terminates at the adductor foramen, where the vessel passes into the popliteal space and becomes the popliteal artery. A line drawn from midway between the pubic symphysis and the anterior superior iliac spine to the posterior margin of the internal condyle of the femur, corresponds to the course of the artery. Superternally, the groove between the vastus internus and the adductors indicates the position of the vessel.

The artery lies at first in front of the femur, but soon comes to be situated to the inner side of the bone.

The femoral vein at Poupart's ligament, and for a short distance below the same, lies internal to the artery.

Opposite the origin of the profunda the vein passes behind the artery and continues in this situation in the middle portion of the thigh. At the lower part of the thigh the vein is behind and slightly to the outer side of the artery.

The artery and vein are enclosed in a common sheath, but separated from each other by a septum. Below Poupart's ligament this sheath of the vessels is reinforced by a process of the fascia transversalis which passes down in front, and one from the fascia iliaca which passes down behind the vessels, to become blended with the common sheath.

The anterior crural nerve at Poupart's ligament lies between the psoas and iliacus muscles, about one-fourth of an inch external to the femoral artery. The internal saphenous nerve lies superficial and external to the artery, beneath the aponeurotic covering of Hunter's canal, but not enclosed in the sheath. The muscular branch from the anterior crural to the vastus internus descends on the outer side of the artery, as far as the middle of the thigh.

According to the relations of the artery to the surrounding soft parts, and especially to the muscles, the following subdivisions of the vessels may be distinguished:

1. A superior superficial portion in the subinguinal fossa or Scarpa's triangle. 2. A middle portion beneath the sartorius. 3. An inferior portion in Hunter's canal.

1. The femoral artery in Scarpa's triangle is very superficial, being covered only by integument, superficial fascia and subcutaneous fat, inguinal glands, and the fascia lata. The direction of the vessel is indicated by a line drawn from the apex of Scarpa's triangle vertically to the base formed by Poupart's ligament. The artery rests on the inner border of the psoas muscle, which separates it from the capsule of the hip-joint. Some filaments from the crural branch of the genito-crural nerve are in front of it, and the branch from the anterior crural to the pectineus passes behind it.

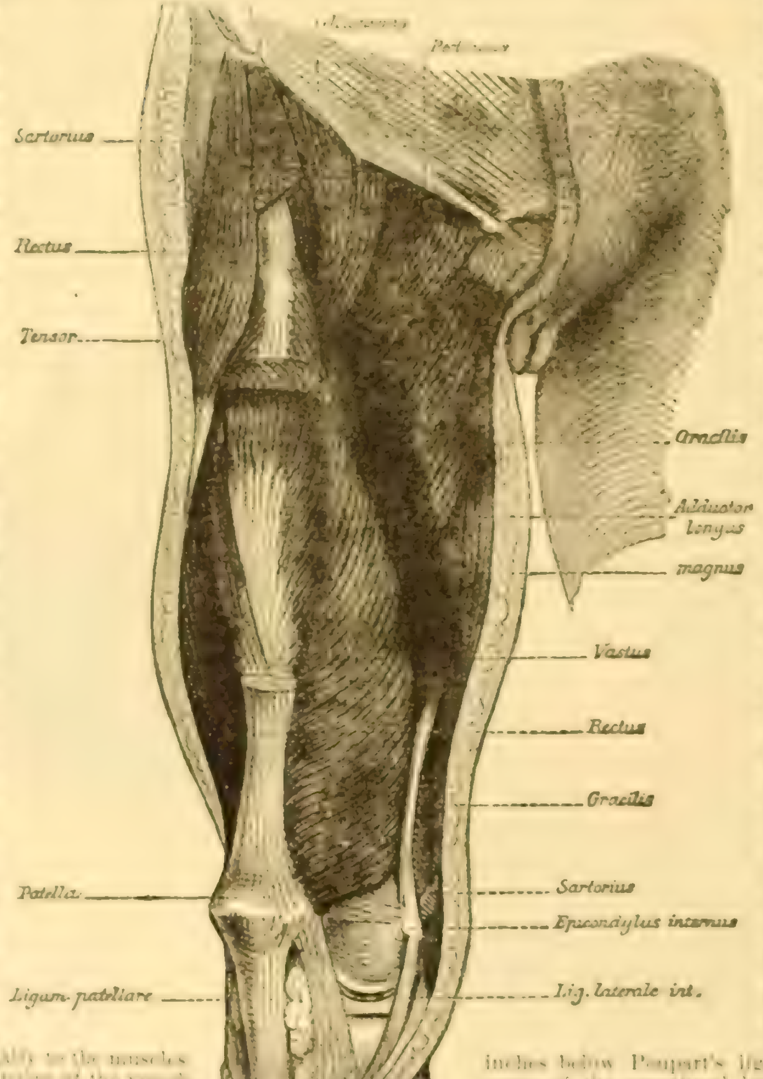

Fig. [illegible].—Anterior View of the Muscles of the Thigh, with the Sartorius and Rectus Removed. (After Henle.)

The relations of the artery to the femoral vein and anterior crural nerve have already been mentioned above.

The artery in this situation gives off its superficial cutaneous branches, and the profunda femoris. The point at which the latter vessel is given off is of considerable importance surgically, as the artery may be tied either before giving off the profunda, or at the apex of Scarpa's triangle (seat of election), or in Hunter's canal. The name of common femoral artery is applied to the vessel from Poupart's ligament to the point of origin of the profunda branch, the continuation of the main vessel being known as the superficial femoral. The first operation would therefore be a ligature of the common femoral, the last two, of the superficial femoral. The profunda arises from the posterior and external surface of the femoral artery one and a half to two inches below Poupart's ligament. Sometimes it is given off higher, or considerably lower, even as low as four inches below Poupart's ligament.

The usual length of the common femoral is one and a half inch, and it may readily be ligated, as it is superficial and of easy access. The operation is, however, not a very successful one, secondary hemorrhage and gangrene of the limb having frequently followed it.

Ligature of the superficial femoral, near the apex of Scarpa's triangle, is the operation most frequently practised. The apex of the triangle is situated about four inches below Poupart's ligament, and on account of the occasional low origin of the profunda branch it has been recommended to tie the artery a little lower than the point indicated. At the apex of Scarpa's triangle the artery is situated behind the inner margin of the sartorius and more or less overlapped by the same according to the muscularity of the subject. The inner margin of the sartorius is therefore the anatomical guide to the artery for ligature in this position. The femoral vein at the apex of the triangle already lies on its posterior aspect.

2. The middle portion of the femoral artery, beneath the sartorius, extends from the apex of Scarpa's triangle to the upper opening of Hunter's canal. At the upper part of this segment of the femoral artery the main mass of the sartorius lies somewhat to the outer side, the inner margin of the muscle covering the artery. In the middle the muscle lies directly in front, and at the lower part more to the inner side. The femoral vein lies behind

and to the outer side. The internal saphenous nerve lies in front of the artery, and in ligature of this portion requires careful separation. In this operation the sartorius must be displaced or divided.

3. The inferior portion of the femoral artery is contained in the adductor canal. The internal saphenous nerve lies superficial and internal to the artery. Behind the artery, and more to the outer side, is the femoral vein. The anastomotica magna is frequently given off in Hunter's canal.

Branches of the Femoral Artery.—In Scarpa's triangle the femoral artery gives off the following small branches:

1. *Superficial epigastric,* ascending to the superficial fascia and integument of the abdomen, after having passed through the saphenous opening.

2. *Superficial circumflex iliac,* to the integument of the groin as far as the crest of the ilium.

3. *The superficial external pudic* (subcutaneous), to the integument of the lower part of the abdomen, penis, and scrotum.

4. *The deep external pudic* (subaponeurotic), passing beneath the fascia lata, on the pectineus and adductor longus, to the external genitals.

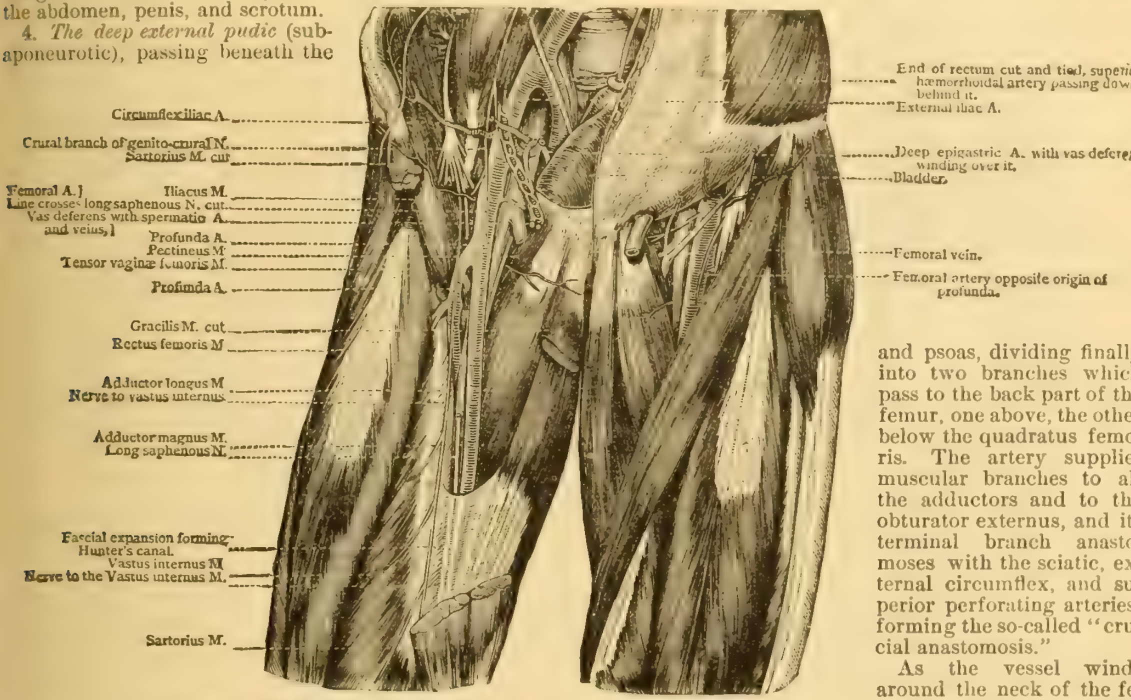
Circumflex iliac A.
Crural branch of genito-crural N.
Sartorius M. cut
Femoral A.
Line crosses long saphenous N. cut.
Vas deferens with spermatic A. and veins.
Iliacus M.
Profunda A.
Pectineus M.
Tensor vaginæ femoris M.
Profunda A.
Gracilis M. cut
Rectus femoris M.
Adductor longus M.
Nerve to vastus internus.
Adductor magnus M.
Long saphenous N.
Fascial expansion forming Hunter's canal.
Vastus internus M.
Nerve to the Vastus internus M.
Sartorius M.
End of rectum cut and tied, superior hæmorrhoidal artery passing down behind it.
External iliac A.
Deep epigastric A. with vas deferens winding over it.
Bladder.
Femoral vein.
Femoral artery opposite origin of profunda.

FIG. 5094.—Surgical Anatomy of Femoral Artery. (After MacCormac.)

The largest branch of the femoral artery is:

5. *The Profunda Femoris.*—This vessel, as already stated, arises from the external and posterior aspects of the femoral artery in Scarpa's triangle, from one and a half to two inches below Poupart's ligament. It passes downward and slightly outward upon the psoas tendon and upper part of the crureus, and then curves inward behind the femoral artery, separated from the same by the profunda and femoral veins. Arrived at the upper or external border of the adductor longus, quite close to its insertion into the bone, the artery passes beneath the muscle, running between it and the adductor magnus, and finally perforating the latter—as the fourth perforating artery—a little above the adductor foramen.

The upper part of the profunda is accompanied by a single vein which lies to the inner side and joins the femoral vein.

The more important branches of the profunda artery are the following:

a. *The external circumflex* arises from the outer side of the profunda, passes between the two main branches of the anterior crural nerve, and beneath the sartorius and rectus muscles, and divides into an ascending and a descending branch; a few small branches being continued transversely over the crureus and through the vastus externus to the back part of the femur, just below the great trochanter, anastomosing with the internal circumflex, sciatic, and superior perforating arteries. The ascending branch curves around the upper part of the shaft of the femur at its back part, beneath the trochanter major, passing beneath the tensor vaginæ femoris, and anastomosing with the internal circumflex, sciatic, gluteal, and circumflex iliac arteries. The descending branches pass behind the rectus femoris to the outer aspect of the thigh, supplying the quadriceps extensor.

b. *The internal circumflex* arises frequently from the femoral artery, instead of from the profunda. Soon after its origin the vessel gives off an internal superficial muscular branch which supplies the pectineus and the superficial adductors. The main trunk continues backward around the inner side of the femur, between the pectineus and psoas, dividing finally into two branches which pass to the back part of the femur, one above, the other below the quadratus femoris. The artery supplies muscular branches to all the adductors and to the obturator externus, and its terminal branch anastomoses with the sciatic, external circumflex, and superior perforating arteries, forming the so-called "crucial anastomosis."

As the vessel winds around the neck of the femur an articular branch to the hip-joint is frequently given off, which passes beneath the transverse ligament, along the round ligament, to the head of the bone. Other branches perforate the capsule and pass along the neck of the femur, supplying the periosteum. These branches are important in conveying blood to the head of the bone in cases of intra-capsular fracture of the neck of the femur.

c. The *perforating arteries,* usually three in number, are given off from the profunda as this vessel passes in front of and between the adductors. They perforate the adductor muscles close to their insertion into the linea aspera, and pass backward to supply the posterior muscles of the thigh.

The middle perforating artery usually supplies the nutrient artery for the femur.

6. *Muscular branches,* varying in number and size (two to seven), are given off from the superficial femoral, supplying chiefly the sartorius and vastus internus.

7. The *anastomotica magna* (art. articularis genu suprema) arises from the lower portion of the superficial femoral in Hunter's canal, and perforates the anterior wall of this canal formed by the tendinous portion of the adductor magnus. The vessel divides into a superficial and a deep branch.

The superficial branch runs in front of the adductor magnus and beneath the sartorius accompanied by the internal saphenous nerve to the fascia and integument covering the internal condyle.

The deep branch enters the substance of the vastus in-

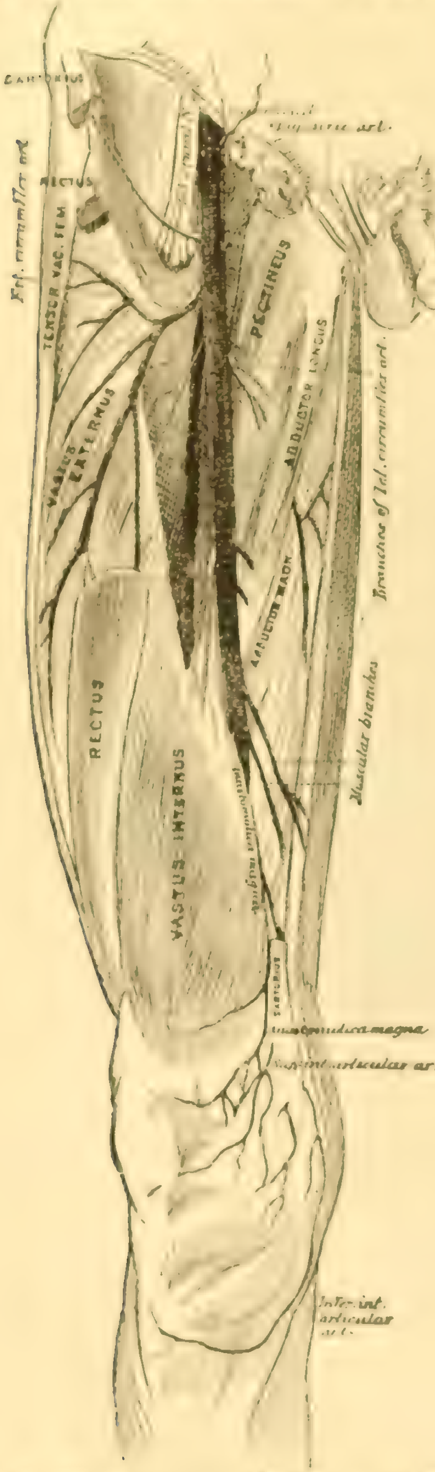

Fig. 4646.—Femoral Artery and Branches. (After Allen.)

ternus, anastomosing with the superior internal articular and anterior tibial recurrent arteries. A branch passes outward above the articular surface of the femur to anastomose with the superior external articular artery.

The *obturator artery* belongs topographically to the pelvic and gluteal regions. A few of its terminal branches pass to be distributed to the structures of the thigh. After emerging from the obturator canal the vessel divides into two branches. The anterior or internal branch passes to the adductors, anastomosing with the internal circumflex artery. The posterior or external branch frequently gives an articular branch to the hip joint and passes to the gluteal region, anastomosing with the sciatic artery. The collateral circulation, after ligature of the femoral artery immediately below Poupart's ligament, is chiefly carried on by means of these anastomoses.

The course and relations of the *femoral vein* have been sufficiently referred to in speaking of the artery. In the lower half frequently two venæ comitantes accompany the artery besides the femoral vein proper, a fact to be borne in mind in applying a ligature to this portion of the vessel.

Nerves.—The deep branches of the anterior crural nerve are:

1. Muscular branches to the pectineus and to the different portions of the quadriceps extensor; the nerves to the vastus externus and internus supply in addition articular filaments to the knee joint.

2. *The internal or great saphenous nerve* accompanies the femoral artery into Hunter's canal, lying in front and somewhat to the outer side of the vessel. Just above the adductor foramen the nerve quits the artery, passing through an opening in the anterior wall of Hunter's canal, usually in company with the anastomotica magna. It then descends vertically beneath the sartorius along the inner side of the knee, piercing the deep fascia and becoming subcutaneous between the tendons of the sartorius and the gracilis.

The *obturator nerve* is derived from the second, third, and fourth lumbar nerves and supplies the obturator externus and adductor muscles, the hip and knee joints, and occasionally the integument of the thigh and leg.

The branch to the obturator externus is usually given off within the pelvis and emerges with the main trunk through the obturator canal.

Immediately after its exit from the pelvis the nerve divides into a superficial and a deep branch.

The superficial branch descends beneath the pectineus, which it occasionally supplies, and gives branches to the adductor longus, brevis, and gracilis.

This anterior or superficial branch usually furnishes a cutaneous filament which descends along the inner margin of the adductor longus, and communicates opposite Hunter's canal with the internal saphenous and internal cutaneous nerves. The deep or posterior branch perforates the obturator externus, supplies this muscle and the adductor magnus and minimus.

Deep lymphatics, five to six in number, accompany the femoral artery, passing between the popliteal and the deep crural glands of the inguinal region.

B. Posterior Region of Thigh.—The *integument* and *fasciæ* have already been described with the general anatomy of the thigh. Beneath the fascia lata is found the *small sciatic nerve*, a branch of the sacral plexus, which, after emerging from the pelvis through the great sacro-sciatic foramen below the pyriformis muscle, descends beneath the gluteus maximus, supplying the same, and then beneath the fascia lata along the back of the thigh to the popliteal space. The nerve in its course gives off several cutaneous filaments, which pierce the fascia lata and supply the integument of the posterior part of the thigh and gluteal region.

The *arteries* of the back of the thigh are: 1. The *sciatic artery*, a branch of the internal iliac, giving off the comes nervi ischiadici, inferior gluteal branches to the gluteus maximus, muscular branches to the muscles on the posterior aspect of the hip, a coccygeal branch to the coccygeal region, and an articular branch to the hip. 2. Terminal branches of the *external* and *internal circumflex arteries*; and 3. Terminal branches of the *perforating arteries* already described with the profunda femoris.

The veins accompany the corresponding arteries.

III. MUSCLES OF THE POSTERIOR GROUP.—1. *The biceps* arises by two heads. One, the long head, arises, together with the semitendinosus, from the posterior and external portion of the tuberosity of the ischium. The short head arises from the middle third of the outer lip of the linea aspera. The two portions unite, forming the outer hamstring tendon, and are inserted into the head of the fibula.

2. *The semitendinosus* arises with the long head of the biceps from the tuberosity of the ischium, and passes around the internal condyle of the femur to the inner aspect of the shaft of the tibia.

3. *The semimembranosus* arises from the anterior portion of the tuberosity of the ischium, behind the quadratus femoris, above and to the outer side of the biceps and semitendinosus, and is inserted into a groove on the inner and back part of the inner tuberosity of the tibia, gaining its median position by passing in front of the biceps and semitendinosus.

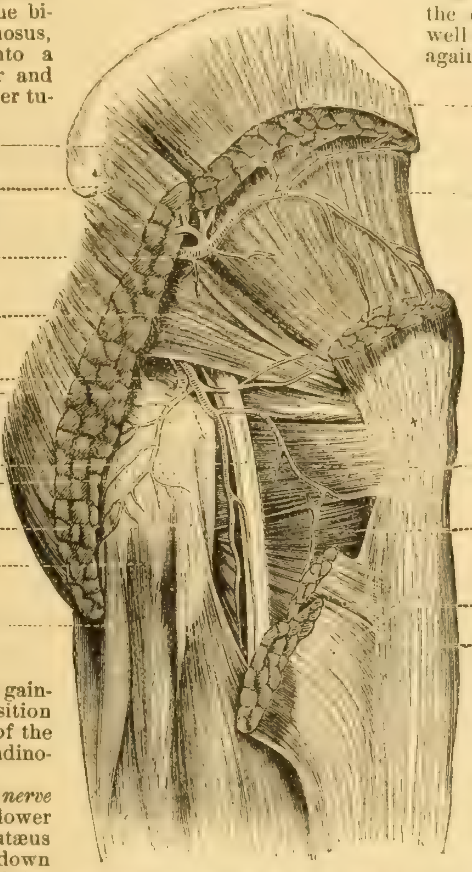
Gluteus maximus M. cut away.
Posterior superior spine of the ilium: guiding lines to great trochanter and tuberosity indicated.
Gluteal A.
Pyriformis M.
Sciatic A.
Internal pudic A.
The cross indicates the most prominent portion of the ischial tuberosity.
Sciatic nerve.
Semi-membranosus tendon.
Long head of the biceps M.
Semi-tendinosus M.
Ischial part of adductor magnus M.
Gluteus medius M. cut away.
Gluteus minimus M
The cross indicates the tip of the great trochanter.
Quadratus femoris M. with obturator internus M. above.
Part of adductor magnus M.
Insertion of gluteus maximus M.
Vastus externus M.

FIG. 5096.—Posterior Region of Thigh and Gluteal Region. (After MacCormac.)

The *great sciatic nerve* emerges from the lower border of the glutæus maximus and passes down the back of the thigh between the trochanter major and the tuberosity of the ischium, under cover of the biceps. At about the lower third of the thigh the nerve divides into the external and internal popliteal nerves. This division may, however, take place at any point between the sacral plexus and the lower third of the thigh.

The nerve supplies articular branches to the hip-joint and muscular branches to the biceps, semitendinosus, and semimembranosus, also a branch to the adductor magnus, in its course along the back of the thigh. After emerging from the lower border of the glutæus maximus, the nerve rests on the adductor magnus with the biceps externally, and the semimembranosus and semitendinosus internally. The nerve is imbedded in a layer of loose areolar tissue which extends between the muscles named from the great sacro-sciatic foramen to the popliteal space. This loose cellular tissue is a favorite site for deep abscesses, and abscesses which form within the pelvis may descend with the nerve along this route to the popliteal space.

The great sciatic nerve is accessible for operation in the middle line of the thigh, just below the gluteo-femoral crease, midway between the trochanter major and the tuberosity of the ischium. The muscular guide is the biceps, immediately beneath which muscle the nerve is found.

George S. Huntington.

THYROIDECTOMY. The history of the operations for disease of the thyroid gland dates from the time of Celsus, who spoke only of cysts of the gland and recommended either extirpation or incision.

Cl. Galenus, Paulus of Ægina, and Albucasis wrote of the extirpation of cysts and of small and completely movable strumata. They called especial attention to the injury to the recurrent laryngeal nerves, as well as to the larger vessels in the neck.

In the thirteenth century Rulandus recommended the employment of the seton or of the hot iron, as well as the extirpation of the capsule, as the best means against a return of the struma.

In 1652 Fabricius Hildanus mentions a case of extirpation which was followed by immediate death.

In 1716 Gottfried Purmann advocated, as the best means of arresting the growth of strumata, the double ligature of the afferent vessels.

In the eighteenth century more attention was paid to the internal treatment and to the use of ointments than to operative measures. It is scarcely probable that any formal operation was performed, as we find the word "struma" was a collective term for a variety of tumors in the neck. It is safe to say that until the middle of the eighteenth century no true thyroidectomy (in the sense in which we use the term) had been performed. With Laurentius Heister (1682–1758) came a new era in the treatment of strumata. He mentions several methods, such as ligature of the pedunculated variety, cauterization of solid nodules, incision and cauterization in cystic nodules, and the shelling or peeling out of solid ones. At this time, 1750, Albert Haller first referred to the compression of the trachea in strumata.

In 1770 Benjamin Gooch first described an extirpation of the thyroid gland, and in 1771 A. T. Vogel described the first typical partial extirpation of the thyroid gland with ligature of the afferent vessels. In 1791 Desault reported the first typical half extirpation with recovery, and in 1800 J. A. W. Hedenus performed the first total extirpation with recovery. Haussleuthner, in 1810, called attention to the mental disturbance following destruction of the thyroid gland.

V. Walther recommended, in 1814, the ligature of the superior thyroid arteries in the treatment of aneurismal strumata.

In 1834 K. J. Beck gave a very succinct account of the method of extirpation, with all the surgical and anatomical details, including a description of the ligature of the thyroid arteries.

From 1850–1875 von Bruns, Schuh, Billroth, Luecke, Kocher, Rossander (1874–1875), and Greene (1871) contributed mostly to the advancement of the operation.

From 1875 to 1886 Luecke, Kocher, Hopmann, Kuster, Albert, Billroth, Wölfler, Rose, Liebrecht, Reverdin, and Socin were the most prominent in advancing the operative measures for the relief of strumata. We can thus see how slowly the operation has advanced from an incision for cysts to what we now consider a safe and thoroughly studied operation, such a method of operation as is practised by Mikulicz, Kocher, Rose, Billroth, or Lebrecht.

Although we must admit that the good results to-day are largely due to the care which we bestow upon the treatment of the wound, we must not overlook the fact that the "technique" of the operation is important and is to be ruled by two principles: the one, complete control of bleeding; the other, the avoidance of any injury to the recurrent laryngeal nerve. Both principles depend upon an accurate knowledge of the anatomy of this region. In no other region are the irregularities in the blood supply so great as in this very organ. As a general rule the vessels can be followed regularly.

The superior horns of both lateral lobes are supplied by the superior thyroid artery from the external carotid artery, which, when the isthmus is present, anastomoses with the artery of the opposite side along its upper border, forming a superior communicating branch. The inferior horns of the lateral lobes are supplied by the inferior thyroid arteries from the subclavian.

In addition to these we have the arteria thyroidea ima from the aorta, the innominate, or branches of either, which supplies when present (in about ten per cent. of the cases) the lower portion of the isthmus and the inner surface of the inferior lobes. The veins are, however, more numerous, larger, and of more importance than the arteries, and an exact knowledge of them is necessary in order to carry out a bloodless operation.

After division of the skin and the platysma muscle we find the venæ subcutaneæ colli. They lie in the superficial fascia and form an irregular plexus between the vena maxillaris externa (facialis anterior) and facialis communis above, and the jugularis externa below. Of these, three branches require special mention. The jugularis externa, beginning above from branches communicating with the vena facialis posterior and vena occipitalis, and ending below at the junction of the vena jugularis interna or subclavia, or either one of them, lies upon the outer border of the sterno-cleido-mastoideus muscle and comes into notice only when the superior horns are greatly enlarged and the oblique incision has been used for the extirpation of the tumor. If such be the case, it must be divided between two ligatures. The venæ jugulares anteriores, a pair of veins united by a transverse branch near the hyoid bone, and receiving branches from the venæ submentales, pass downward along the median line, gradually diverging until they reach the anterior border of the sterno-cleido-mastoid muscle, where they join the venæ jugulares obliquæ, and with them pass beneath this muscle, emptying into the vena subclavia or vena jugularis interna or externa. The vena jugularis obliqua, beginning above from branches of the vena facialis communis, or vena thyroidea superior, runs along the inner border of the sterno-mastoid muscle until it meets and joins the vena jugularis anterior. It also continues by a branch across the median line, which unites with a similar branch from the opposite side. This transverse branch occurs at a variable distance above the incisura sterni. After division of these subcutaneous veins and their ligation the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles are to be divided upon a director, especially in all strumata of any size. The struma is now exposed, with its large veins upon and within its external capsule. Without disturbing the tumor one proceeds to ligate the arteries and veins of the thyroid itself. Of these the first is the vena thyroidea superior, which has the position and course of the artery of the same name. It can be ligated with the artery in one ligature. A second branch which should be ligated is the branch of this vein which communicates with a branch from the opposite side along the upper border of the isthmus, forming the superior thyroid communicating branch. This branch does not communicate with that of the opposite side when the isthmus is wanting. Its ligation is necessary, for it often receives a branch from the vena jugularis anterior. A third branch requiring ligation is the vena thyroidea superior accessoria, which is found upon the external border of the lateral lobe at a variable distance below the vena thyroidea superior. It empties into the vena jugularis interna and its branches receive the blood from the anterior surface of the superior horn of the lateral lobes. When the veins in any struma are marked, we generally find some important veins at the lower surface of the struma. These are the venæ thyroideæ imæ. The left is often small, and ends in the vena anonyma sinistra. The right is larger, and ends in the vena anonyma dextra or sinistra. They receive the blood from the lower border of the isthmus and from the inner and anterior surface of the inferior horns. They often form a large plexus in front of the trachea and communicate with the venæ thyroideæ inferiores. Their ligation is necessary, and is to be done below the isthmus in front of the trachea.

The next veins of importance are the venæ thyroideæ inferiores. They receive the blood from the posterior surface of the inferior horn of the lateral lobe. They are often wanting, and when this is the case the venæ thyroideæ inferiores accessoriæ are correspondingly enlarged.

The venæ thyroideæ inferiores accessoriæ correspond to the venæ thyroideæ superiores accessoriæ, and are situated at a point above the venæ thyroideæ inferiores, having a more transverse course in the neck. They receive the blood likewise from the posterior surface of the inferior horns of the lateral lobes and join the lower portion of the venæ jugulares internæ. This vein is always very large when the vena thyroidea inferior upon the same side is wanting. Moreover, both of these veins may be wanting, and the whole mass of venous blood from the inferior horns may be carried through the venæ thyroideæ imæ, which latter are by far the most important of the venous branches found in this region of the neck. The next important step after the ligature of the arteries and veins is the avoidance of any injury to the recurrent laryngeal nerve. Wolfler first drew attention to this point, and it is not difficult to avoid the nerve, if one remembers the relation of the inferior thyroid artery to the nerve at the time of ligation. Before ligation one must secure its complete isolation, and must not ligate near the trachea.

From the aorta, or the innominate artery, the nerve advances laterally parallel to, and slightly in front of, the posterior end of the tracheal rings toward the venous plexus of the inferior thyroid, and accessory inferior thyroid veins on the posterior surface of the struma. Here it is very necessary to avoid the nerve, and in order to accomplish it, one must keep close to the capsule of the gland. This is especially demanded in the neighborhood of the isthmus, for it is just here that the union is very intimate, and any unguarded incision or ligation of arteries may be attended with injury to the nerve. This is the reason why in the operation one secures at first a completely bloodless wound before attempting a separation of the struma from the trachea. The relation of the inferior thyroid artery to the nerve is that, in its course from the thyroid axis, it passes transversely and slightly ascending in the neck, lying at first upon the outer side of the nerve, then behind it, and when it reaches the tracheal rings ascends upon its internal surface and divides there into its branches to supply the posterior surface of the lateral lobe. When the artery divides into its branches early in its course, some of them will pass over the nerve, while the rest pass behind it. On this account one must tie the artery either close to the gland at its point of division, or with a double ligature on the lateral surface of the lobe before it has come in close relationship with the nerve. All haste or tearing of the tissue in this neighborhood must be avoided, for in such a procedure one runs great risk of injuring the nerve.

Having gone over the more important points in the anatomy of the venous, arterial, and nervous supply, we will describe the operation, dividing it into three steps:

1. Exposure of the struma, *i.e.*, the mode of incision and the tissues cut.
2. Isolation of the lateral lobes with the ligature of the vessels.
3. Separation of the lateral lobes and isthmus from the trachea or œsophagus.

Of the various incisions used in the operation of thyroidectomy, we prefer that of Kocher to the median incision or to that carried along the anterior border of the sterno-mastoid muscle. The advantages gained by Kocher's incision are that it allows a more perfect and complete survey of the whole field of the operation, and an excellent chance to ligate the veins and arteries without difficulty.

This incision commences at the manubrium sterni in the median line, and ascends as far as the cricoid cartilage. This portion of the incision divides the skin and superficial fascia, and avoids the veins, with the exception of the smaller anastomoses between the oblique jugular veins, which, as a general thing, lie just above the incisura sterni. The upper portion of the incision passes from the cricoid cartilage upward and outward toward the anterior border of the sterno-mastoid muscle, until one arrives at the upper limit of the lateral lobe. The advantages offered by this mode of incision over the median and that along the anterior border of the sterno-mastoid muscle are the more perfect exposure of the trachea where the thyroid gland is attached, and of the inner surface of the inferior horn of the lateral lobe where the large veins are present, which, in *goître plongeant* (struma substernalis), must be rendered free for ligature. In addition, the upper oblique portion of the incision, besides dividing the skin and platysma muscle, crosses the anterior, oblique, or external jugular veins transversely, or at least obliquely, so that they may be easily secured with double ligatures before proceeding further with the operation. The sterno-hyoid, sterno-thyroid, and omo-hyoid muscles are now divided upon a director in the line of the oblique portion of the incision.

By the use of blunt hooks in the outer portion of the wound these muscles, together with the sterno-mastoid muscle, are drawn outward, and the lateral lobe is completely exposed, so that the veins and arteries supplying it may be easily secured before proceeding to the isolation of the tumor from the surrounding parts.

To do this we at first follow the inner border of the lateral lobe to its highest portion, so as to ligate with a double ligature the superior thyroid artery and vein as near to the main trunk as possible. They can be ligated together and need not be isolated from one another for the ligature. From this portion we descend upon the outer border of the lateral lobe until we meet with the accessory superior thyroid vein, when it is present, and, after the application of a double ligature, divide it. The superior communicating thyroid vein upon the upper border of the isthmus is next ligated, together with the artery, should the latter be present. The upper half of the lateral lobe is now free from all vascular connection, and with the finger one can easily strip from it the loose connective-tissue capsule in which it lies. It is now raised as much as possible with the fingers alone, or when, as in substernal strumata, dyspnœa is impending, with a strong pair of blunt forceps. We have thus a perfect view of the venæ thyroideæ imæ, which are often large and must be ligated with double ligatures in more than one place so as to shut off all blood from the inferior communicating thyroid vein. This is easily accomplished, and we follow the lower border of the lateral lobe, meeting the inferior thyroid vein, which we ligate with double ligatures. Proceeding along the outer border of the lobe, we meet the inferior accessory thyroid vein, which we likewise ligate. The struma is at this stage attached only at its pedicle, *i.e.*, at the isthmus on the upper tracheal rings. It is raised completely from the underlying tissues, and turned upon itself toward the median line of the neck and held in this position by the hand of an assistant. We proceed to look for the inferior thyroid artery, which we find in the lower angle of the wound. It is secured by a double ligature as near as possible to the point where it is passing behind the common carotid artery. This is not difficult, for from its transverse or oblique course it is readily distinguished. Its isolation must be carefully done, and the ligatures must enclose only the artery itself. This being accomplished, we proceed to separate the tunica propria of the gland from the tissue covering the posterior surface until we reach the isthmus. It is necessary in this region to keep close to the gland in order to avoid the recurrent laryngeal nerve as well as the vessels entering the posterior surface of the gland. Having ligated such arteries as bleed in this neighborhood, we have only the isthmus left to manage. This we do in one of two ways. Either the isthmus is completely separated from the trachea with the knife, and such arteries as bleed are caught with clamps, or we keep out of the way of the nerve, the artery, and the trachea by making use of Mickulicz's method of avoiding any injury to these structures. This method consists in fastening the struma with a clamp, and by squeezing out the glandular portion of the struma he leaves a pedicle which consists only of the tunica propria of the gland. This pedicle, which is made at a point where the gland is not attached to the trachea, can be subsequently treated just as in the case of ovarian tumors.

By either procedure the nerve is safely avoided. Kocher had in 1883 twenty cases, of which sixteen showed no paresis of the nerve by laryngoscopic examination. In one case the nerve was paralyzed before the operation. In two cases, though no hoarseness remained after the operation, the patients were not subjected to a laryngoscopic examination. In one the voice remained weak, though otherwise perfect, after the operation. In this case, also, no laryngoscopic examination was made. In the 322 cases reported by Liebrecht, section of the recurrent laryngeal nerves was certain in 9 cases and doubtful in 4 cases.

This incision (Kocher's) suffices in many cases of total extirpation. Should it not be sufficient, one can add a second similar to the upper portion of the first incision, making a **Y**-shaped incision. This is to be preferred to the **V**- or **T**-shaped incision, as it produces less injury to the skin with a more perfect exposure of the field of operation. Should tracheotomy be performed in this operation ? Rose prefers it in order to avoid the mediastinitis, in cases of dyspnœa, for the orthopædic treatment of the deformed and softened trachea, and to render the operation easier. Wölfler raises as an objection to this the fact that of 48 cases in Billroth's Klinik just those cases did badly in which tracheotomy was performed. Of these, 43 were not tracheotomized, and all lived ; 5 were tracheotomized, and 3 of them died. Kocher adds also 43 cases, in which tracheotomy was performed in 4 cases ; 3 of these 4 died. It is impossible, when tracheotomy has been performed, to keep the wound aseptic. The air and mucus from the trachea escape easily beneath the dressing and infect the wound. On the other hand one must, when tracheotomy has been performed, prevent the escape of the discharges from the wound into the trachea, where, decomposition occurring, a septic bronchitis and broncho-pneumonia will certainly result. If one must perform tracheotomy, it is better to make use of the open treatment. The mediastinitis for the avoidance of which the tracheotomy (Rose) is performed occurs only when sepsis is present in the wound. The best means of avoiding this or, at least, of avoiding a factor in its production, is not to open the trachea. Moreover, it is not yet thoroughly determined whether the tracheal cannula is able to restore the trachea to its proper shape. Rose has certainly obtained the honor of calling attention to the inflammatory softening of the tracheal rings and the consequent scabbard-shaped (säbelscheidenförmig) contour, as well as the angular bend in the wall of the trachea resulting from atmospheric pressure or from movements of the head and neck, when the struma has been removed.

This condition he explains by showing how, when the trachea and larynx are removed from the body and suspended, the larynx being downward, the softened trachea will form a sharp angle at the point of softening while the healthy trachea hangs straight or with a gentle curve. Kocher has shown that the same will occur in the healthy trachea at the point where tracheotomy has been performed, and says that as the cartilages will only unite by connective tissue, the same conditions and dangers will exist after tracheotomy as are present in a trachea softened by strumata. Tracheotomy is to be avoided in this operation, and performed only where immediate danger of suffocation exists. Such danger is generally due to stenosis of the trachea from the pressure of bilateral strumata, or to severe tracheitis or a double paralysis of the recurrent nerves. In all cases it is best to delay the tracheotomy as long as possible, allowing an assistant to press with the finger upon the trachea from before backward, maintaining thus an oval or round lumen and giving a free ingress to the air. This procedure is continued until the operation is finished, when, if the rings are not softened to the last degree, and if the lumen is kept, the danger will not recur. It is proposed also to sew the walls of the trachea to the adjoining muscles or soft parts in order to give the necessary support to the trachea and thus secure more perfect asepsis in the wound, rather than to tracheotomize the patient with the necessary danger of subsequent infection.

During the operation many complications can occur, and of these the hæmorrhage deserves attention. This takes place if, during the isolation of the struma, we omit to tie all veins and arteries with a double ligature. Excessive bleeding occurs if we accidentally injure the capsule of the gland with sharp hooks or forceps. It is best not to use such instruments, but to confine oneself to blunt instruments and the finger for raising or turning the struma.

If hæmorrhage does occur from the extracapsular vessels they are to be compressed immediately by the finger, and subsequently caught with artery clamps beyond the finger. They can then be tied or the forceps can be left hanging in the wound until the operation is completed. The possibility of the entrance of air into the vein is thus best avoided. Another complication liable to occur during the operation is a sudden asphyxia. This is due either to a paralysis of the recurrent laryngeal nerves as the result of injury from the knife or forceps (some maintain that the same result will occur when too strong or too long-continued solutions of carbolic acid are used upon the wound), or to a sudden closure of the trachea either from torsion or from compression of its wall due to too forcible dragging, raising or turning of the whole struma or one lobe during its isolation, or to deformation of the trachea by which its walls are approximated to one another and its lumen is diminished in size as a consequence of the long-continued pressure of the struma. Lastly, as a cause we have the softening and disappearance of the cartilaginous rings (Rose), in which case the trachea is practically a membranous tube whose walls collapse from atmospheric pressure as soon as the support given them by the struma is removed. Some deny this complete absorption of the tracheal rings, yet preparations show it sufficiently well to demand a belief in its existence.

More frequently, however, the compression of the walls of the trachea occurs, and in this case the slightest lateral deviation of the head and neck results in an angular bend in the wall and a complete closure of the lumen.

Such deformity in the trachea occurs more frequently from approximation of the lateral than from that of the anterior and posterior walls, or from a sinking in on one side only. Should such an accident occur it is not absolutely necessary to perform tracheotomy, for we can make use of Kocher's method for re-establishing the form of the trachea. This method consists in passing a suture through one lateral wall of the trachea without injuring the mucous membrane, then over the anterior surface of the trachea and through the lateral wall of the opposite side. The ends of the suture are then drawn tightly and tied over the anterior surface. In this way the lateral walls are drawn away from one another, the sharp anterior angle is pushed backward, and the rounded form of the trachea re-established. In cases of complete absorption of the tracheal rings and in bilateral paralysis of the recurrent nerve, tracheotomy is demanded. Unilateral paralysis produces only a hoarseness in the voice or breathing, and according to Wölfler, in addition to these symptoms there occur frequent attacks of choking, as a result of the oblique position of the epiglottis and the insufficient closure of the aditus ad laryngem. Other than this it does not demand our attention. Injury to the œsophagus may occur in the extirpation either of malignant strumata or of retro-œsophageal strumata in case the operation is not carefully done. The separation of the struma from the œsophagus is generally easily accomplished, but where the capsule is closely adherent to the œsophagus the struma must be divided near it and the parenchyma scraped out, leaving the capsule intact and attached to the wall of the œsophagus.

The indication for the operation of thyroidectomy, either partial or complete, can be said to exist in cases in which most therapeutic measures cannot be used, or in which such remedies have been shown to be of no avail, and when the symptoms demand speedy measures for their relief. Formerly the cosmetic effect was considered an indication for the operation. Julliard, Reverdin, and Kocher, however, have shown that the extirpation of this gland is followed by after-effects upon the general organism, that in young people a condition of cretinism with cachexia strumipriva, as well as tetany (Billroth), is often observed. Complete extirpations are reserved for those cases which give dangerous symptoms of impending strangulation, and in this group are classed sarcomatous or carcinomatous strumata, and struma cystica with numberless disseminated pus cavities in the gland. Further we may include struma retro-pharyngea, retro-œsophagea, retro-sternalis, and struma circularis, which surrounds both trachea and œsophagus. Finally we include also struma lateralis, which by its pressure upon the trachea deforms it, narrows it in its lateral diameter, softens its rings, or so twists it upon its axis as to deform and diminish the size of its lumen, and partly through this mechanical pressure and partly through the pressure paralyses of the recurrent nerves causes the danger of suffocation.

In all cases of partial involvement of the thyroid the removal should be partial so far as concerns the gland. In this way the sequelæ are more completely and effectually excluded.

The mortality following the operation of thyroidectomy has been steadily lowered since 1850.

According to Süskind and Wölfler the mortality of all cases operated upon prior to 1850 was forty-one per cent. Kocher gives as the death rate up to the year 1877, comprising 146 cases, a percentage of 21.2 per cent. From 1877 to 1888 there were 28 cases of malignant struma with 16 fatal cases, giving a mortality of 57.1 per cent, and 240 non-malignant cases with 28 deaths, a mortality of 11.6 per cent.

In 1888, in the clinic at Berne, there were 43 cases in which thyroidectomy was performed, with 3 deaths; mortality, 6.9 per cent. Of these 43 cases 4 were malignant strumata with 1 death; mortality 25 per cent. The remaining 39 were non-malignant in nature, with 2 deaths; mortality, 5.1 per cent. Zesas reports 50 cases from 1880 to 1887, with 2 deaths; mortality, 4.1 per cent. Liebrecht gives a table of 422 thyroidectomies for benign goitre, with a mortality of 7.92 per cent. Bruns and Rotter together report 50 cases with 30 deaths, a percentage of about sixty.

Kocher, in summing up his cases for the last five and one-half years, gives 250 cases with 6 deaths; 2.4 per cent. Of these there were 3 in 20 cases of malignant disease, and 1 in 5 cases of Basedow's disease. Leaving these out, we have for simple goitre 0.8 per cent. Of the two remaining, one was a death from chloroform poisoning, the other was in the last stage of asphyxia when operated upon.

As to the development of cachexia strumipriva, we find that the largest collection of cases was made by the Clinical Society of London. This report comprises 277 cases of total thyroidectomy in all. In 22 cases the goitre returned, or hypertrophy of the accessory thyroid glands followed. In these no symptoms occurred. In 186 cases no symptoms of cachexia strumipriva were present, although no such recurrence of the goitre took place, nor was there any observable compensatory hypertrophy of accessory thyroid glands. In 69 cases there were symptoms present suggestive of cachexia strumipriva. We have thus 69 cases in 186 in which no recurrence of the goitre nor any hypertrophy of accessory glands was found, and yet in these there were symptoms of cachexia strumipriva in thirty-three per cent. In partial thyroidectomy we find that in 550 cases symptoms were present 6 times; one per cent.

These symptoms appear clinically in two forms. The first form comprises all those cases in which the symptoms are well marked. The second form embraces those cases in which only a few of the symptoms are present and these symptoms are not permanent, but disappear in from three to four months. Such cases have been observed by Julliard, Reverdin, Baumgärtner, and Zesas. Such symptoms are seen mostly in the mental sphere. The patients become inattentive, falling asleep when talking to anyone, and showing slowness in all mental actions.

If we seek for a cause of these transitory symptoms following the operation, we shall most probably find it in the fact that the portion of the gland remaining after the operation was not sufficient to carry on the function of the gland, and only when it hypertrophied did we find any diminution in the symptoms. Such an office might be carried on by the accessory thyroid glands, and Streckheisen, Zuckerkandl, and Gruber have shown that these accessory glands are by no means uncommon. These are divided, according to their position, into superior and inferior median, lateral, and posterior glands. Of these, careful observations have been made on the median glands only. The superior median arise from the processus pyramidalis, either being connected directly with it or without any connection, or they occupy its place entirely. The processus pyramidalis, which often occupies the position over the thyroid cartilage as far as the hyoid bone, is much more frequently present than was formerly suspected. This processus pyramidalis was present in from sixty-eight to seventy-four per cent. of the cases examined.

Of the superior accessory thyroid glands, *i.e.*, those situated in the space between the isthmus of the thyroid gland and the hyoid bone, Streckheisen found them 33 times in 153 cases; twenty-one per cent. Of these 33 cases, 16 times there was also present a processus pyramidalis. Of the glands above the hyoid bone (the suprahyoid accessory thyroid glands) Zuckerkandl found 57 in 200 cadavers examined for this purpose; twenty-eight per cent.

In 130 cases examined by Streckheisen for accessory thyroid glands, 36 times glands were found, either præhyoid, suprahyoid, epihyoid, or intrahyoid; *i.e.*, twenty-seven per cent. Gruber found the superior accessory glands to occur in one case in thirteen, and the lateral accessory glands once in ten times. Madelung has shown that the lateral accessory glands occupy very irregular positions in the lateral portion of the neck, but are generally close to the lateral lobes of the thyroid glands between the lower jaw and the clavicle and sternum. The inferior glands are situated below the isthmus upon or beside the trachea. Sometimes they lie deeply within the thorax, upon the superior or posterior surface of the aorta (Carle). The posterior accessory glands are situated at the junction of the pharynx and œsophagus and close to the posterior surface of the lateral lobes, or between the trachea and œsophagus, or between the œsophagus and vertebral column. In four cases accessory thyroid glands have been found within the trachea. We may thus compute, from the frequency with which these glands have been found, that in about one-half of the cases there will be accessory glands present. It is very probable that with a more intimate knowledge of these glands their frequency will be found to be greater.

The pathogenesis of this cachexia has been variously explained.

1. The theory is that it results from a diminished amount of oxygen on account of the atrophy of the trachea, which latter was due to the ligature of the thyroid arteries (Kocher).

2. Baumgärtner seeks the cause in an imperfect opening of the glottis due to disturbances of innervation, and later to changes in the sympathetic nerves as the result of mechanical or chemical injury in the wound, which produce an ascending neuritis extending to the cervical ganglia and central organs.

3. Gussenbauer, Mikulicz, and J. Wolff ascribe the cachexia to the injury to the nerves during the operation.

4. L. and A. Reverdin believe the cause to reside in vaso-motor disturbances dependent upon a centre situated in the thyroid gland.

5. .Bircher states that the cause is not the removal of the thyroid gland, but that there is a general infection of the system, whose first stage is the development of the goitre and whose second stage is seen in the symptoms characterizing cretinismus.

6. P. Bruns ascribes to the thyroid gland the function of aiding certain metabolic processes, which are indispensable to the normal activity of the central nervous system.

We may compare these various views with the results of the experiments upon animals. The latter show us that: 1, The total removal of the thyroid gland with the accessory glands produces death; 2, in the removal of one-half of the thyroid gland, with hypertrophy of the remaining half, no symptoms follow; 3, with atrophy of the remaining half, symptoms do follow; 4, in the removal of one-half of this half, with hypertrophy in the portion remaining, no symptoms are observed; 5, in the removal of the whole gland, with hypertrophy of the accessory glands, *i.e.*, superior, lateral, or aortic thyroid, no symptoms have followed (Halsted). We may also add to these experiments the clinical observations as collected by the Clinical Society of London, and the exact physiological investigations of Horsley and Fuhr. As a result of all these, we are led to the belief that the symptoms following the loss of the thyroid, either from operation or as a result of disease, should be ascribed not to any injury to nerves or vessels in the neck, nor to any general disease existing before the operation, but to the loss of a function which is indispensable to proper activity of the nervous system.

Dependent upon the observations that the cachexia will not occur if a portion of the gland remains, Mikulicz has recommended his so-called *resection* of the thyroid gland, in order not only that a portion of the gland may be left, but also that any injury to the nerves or vessels may be avoided. Instead of this mode of operation, but for the same reasons, Wölfler recommended the ligature of the thyroid arteries in order to produce an atrophy of the gland. Such a method might be of advantage in the vascular or aneurismal variety, but certainly not in the colloid or cystic forms. Rydygier has lately reported sixteen cases, in fifteen of which all four arteries were tied, in one case two arteries. They were observed by him for one and one-half year, with no symptoms of cachexia strumipriva following. He recommends the ligature of the arteries for recent cases of parenchymatous goitre. The method of ligation for the superior thyroid artery is the usual one along the anterior border of the sterno-mastoid muscle. The inferior thyroid artery is ligated either by an incision along the anterior border of the sterno-mastoid muscle (Velpeau) or in the cleft between the sternal and clavicular portions of the same muscle (v. Langenbeck). On account of the many difficulties both in the topography and in the depth at which one must work, Drobeck has devised a somewhat easier method. An incision is made beginning one or two centimetres above the clavicle on the lateral border of the sterno-mastoid muscle and ending at the level of the thyroid cartilage. The subclavian triangle is exposed, and the contents pushed aside until one finds the scalenus anticus muscle. Here are seen the phrenic nerve and the ascending cervical artery. The phrenic nerve and muscle are covered by the deep fascia. The internal jugular vein, carotid artery, and vagus nerve are held to the inner side by a blunt retractor. The carotid tubercle is felt. The artery lies below it 1 ctm. in old people, and 2 to 3 ctm. in younger people, on the inner border of the scalenus anticus muscle. Care must be taken that no injury occurs to the vertebral vein and artery. The cervical fascia must be divided before ligation. Rydygier prefers an incision situated 2 ctm. above the clavicle and parallel to it and about 6 to 8 ctm. long, which crosses the sterno-mastoid muscle so that a little less than one-half lies over the muscle. In other respects the method is similar to that of Drobnik. He claims for this a cosmetic effect, as the cicatrix lies beneath the collar and is not seen. Rydygier also prefers, for the same reason, i.e., a better cosmetic effect, in the ligation of the superior thyroid artery an incision at a right angle to the inner border of the sterno-mastoid muscle. The intra-capsular or intra-glandular enucleation of the struma, as recommended by Julliard and Socin, however, seems to be the most certain and radical of the methods for partial extirpation, with the slightest possible danger from hæmorrhage or injury to important nerves. For cystic strumata the intracapsular enucleation, first recommended by Julliard, seems to be the safest and least dangerous of all methods. It requires the shortest time for healing and is easily accomplished. In the parenchymatous strumata the intraglandular enucleation recommended by Socin and Garrè is applicable to those cases in which small or moderately large nodules are present, and are distinctly circumscribed. The bleeding is more abundant than in the cystic variety, in which it is very slight, as the vessels of the capsule are already obliterated.

This intracapsular or intraglandular enucleation is, moreover, less liable to be followed by tetany or cachexia strumipriva than other modes of partial thyroidectomy. In fifty cases Socin saw no case of tetany or cachexia. Should the parenchymatous goitre involve the whole or one half of the gland, or be composed of a large number of cysts and nodules, not covered with the parenchyma of the gland, a partial extra-capsular enucleation is to be preferred to the intra-capsular, as the bleeding is much less by the former and the time required for the operation is less. In just such a case, P. Bruns lost his first case in seventy consecutive operations.

If we thus consider the methods of operation for strumata, we should select when possible the intra-capsular or glandular enucleation; when this is not possible, partial or total thyroidectomy. We may thus hold to the general rule, that when the disease is circumscribed we are to make use of some form of intra-capsular operation, and when we have to do with a diffuse disease we must use the extra-capsular operation.

Of the first variety, we may include Socin's method of enucleation. This is especially applicative to all cases of cysts, and small or moderately large and distinctly circumscribed nodules in which the vascular supply is not excessive. Kocher's evidement or evacuation differs from the enucleation in that, instead of dividing the glandular capsule down to the struma and shelling it out, he incises immediately through the strumatous nodule, and removes it either with the fingers, or with a sharp spoon. This method Kocher himself recommends where the separation of the strumatous nodule from its surrounding tissue is too difficult and bloody, or where during an operation dangerous symptoms of suffocation are present.

It is to be recommended especially for those cases consisting of large and soft, but circumscribed, nodules with abundant vascular supply.

Of the second variety we may include the resection of Mikulicz or Kocher, and the extirpation.

Kocher's resection has been recommended to supersede Mikulicz's operation, simply on account of the possible danger of injury to the nerves in the application of the ligature to the stump. Such a result, however, has not been present in those cases reported by Mikulicz. This method, which is to be considered the one applicable to the greater number of cases of struma, except in the malignant, diffusely infiltrated, and the diffuse hypertrophic strumata for which extirpation is alone suitable, consists in two principal steps:

1. If we wish to preserve as much as possible the function of the gland, we omit the ligature of the superior and inferior thyroid arteries, if not, this is done as in the case of extirpation, early in the operation. 2. After the exposure of the anterior surface of the struma, the isthmus is ligated. A vertical incision in the thyroid gland is now made at the base of the struma, down to the middle of nodules, and with the scissors or knife the gland is separated from the inner and posterior surface of the struma (all bleeding being stopped as one advances), until one arrives upon the outer edge of the posterior surface, where there is no danger of injuring the recurrent nerve. Here the glandular capsule is again divided upon the outer side of the struma. This is practically an enucleation with a circular division of the gland.

This operation has the advantage that as much healthy glandular tissue may be left as is possible. It is a safe method so far as concerns the injury to the recurrent nerve.

Mikulicz's method is equally advantageous, but requires some care in the clamping and ligature of the pedicle, so as not to include the nerve. In his hands this difficulty has not been present, and it thus recommends itself for adoption in the same class of cases.

Extirpation, either partial or complete, must be reserved for cases of malignant, diffusely infiltrated, or hypertrophic and diffuse strumata. *Frank Hartley.*

TOBACCO HABIT. The term tobacco habit is employed to designate the custom of using tobacco in any form, whether by smoking, by chewing, or by snuffing; but the phrase has also acquired a more restricted sense, meaning the over-indulgence in tobacco, which is characterized by definite symptoms of poisoning, mainly of a dyspeptic and neurotic character. Since there are all degrees of this habit, it is best to consider, first, briefly the properties and physiological action of tobacco; secondly, the general effects of its use; and finally, the special symptoms of severe tobacco poisoning.

Tobacco is made from the dried leaves of an annual plant called *Nicotiana Tabacum* Linné (Nat. Ord. Solanaceæ). It was found, on the discovery of America, to be used by the natives as far north as Virginia. Its consumption did not become general among civilized people for some time thereafter. M. Jean Nicot, a French ambassador to Portugal, first brought the attention of scientific men to it in 1560, and made it fashionable in France; hence the name Nicotiana. It was introduced into England in 1565, by Sir John Hawkins. The plant grows from three to eight feet high, and bears light greenish, funnel-shaped flowers.

The valuable properties of tobacco reside only in the leaves, which are from fourteen to twenty-four inches long, six inches wide, oval or ovate, lanceolate, acute, entire, thick, heavy, pubescent, friable, bright green if fresh, mottled brown, if dried. As the plant grows they become oily and semi-resinous, and when dried and "cured," by partial sweating, the aroma increases and the flavor improves. They have a nauseous, bitter taste and strong, peculiar odor. The darker leaves are the stronger.

Tobacco contains: 1. Nicotine, an alkaloid which is the most active principle. 2. Nicotianin—"tobacco camphor"—got by distillation of the leaves (fresh or dry) with water. It is a fatty matter, occurring in minute acicular crystals. It has little taste, but a tobacco odor. 3. Albuminous bodies. 4. Resinous matter. 5. A large amount—sixteen to twenty-seven per cent.—of inorganic salts. The ash contains about twenty-five to fifty per cent. of lime, and thirty per cent. of potassium salts. The principal acids represented are nitric, phosphoric, and malic. The unusual proportion of inorganic matter makes a tobacco crop very exhausting to the soil.

NICOTINE (nicotia) was first isolated by two German chemists, Posselt and Reimann, in 1828. It occurs in tobacco as a malate, in proportions varying between two per cent. and eight per cent. Good Havana contains two per cent., and Virginia 6.9 per cent. (Orfila). The cultivation of tobacco aims at the increase of the aromatic principles and the diminution of the nicotine. Nicotine contains nitrogen in greater proportion than any other product of its class. Pure nicotine is a volatile, inflammable, oily liquid, soluble in water, alcohol, ether, and oils. Exposed to light, it turns red-brown. With acids it crystallizes. It has a hot, sharp, bitter taste, and an alkaline reaction. The odor is feeble if cold, irritant if the alkaloid is heated. It is obtained by distillation with an alkali.

Nicotine, when injected into an animal, at first slows the heart without enfeebling the force of contraction. It may even stop the beats for a few moments, after which the heart regains its normal rhythm, but stimulation of the vagus is without effect. Experiments with other alkaloids, like muscarine, assist in determining the mode of action of nicotine. When the heart has resumed beating after nicotine poisoning, muscarine, which is a known cardiac muscle poison, will bring it to rest permanently. It is, therefore, shown that nicotine does not poison the heart muscle, but it first excites the terminal filaments of the vagus and slows the heart; it then exhausts them (Foster), preventing other alkaloids from affecting them, and allowing the heart to beat faster under the influence of sympathetic or of intrinsic stimulation. This disturbance, in greater or less degree, of the balance of nerve forces acting upon the heart, accounts for the palpitations which characterize the tobacco habit; and the fact that nicotine does not destroy the heart muscle power makes it rarely fatal as a cardiac poison.

Nicotine injected into warm-blooded animals causes excitement, dyspnœa, muscular tremors, evacuation of urine and fæces, staggering, clonic convulsions, paralysis, and death. It affects all classes of animals, but does not particularly injure plants; tobacco fumigations are therefore used in green-houses to destroy insect life. Some animals, like goats, can eat tobacco leaves with impunity, but they are severely poisoned by the fumes (Richardson). Nicotine in man causes vomiting, purging, "sinking" at the epigastrium, vertigo, muscular tremor and weakness—all the symptoms of acute tobacco poisoning. Nicotine is far more active than tobacco itself, and it causes death quicker than any other poison except prussic acid (Stillé). One drop kills a rabbit in three and a half minutes. A thirty-second of a grain causes toxic symptoms in man, and one-sixteenth of a grain has produced muscular spasm and other effects lasting for three days.

One case of death in three minutes has occurred (Taylor), and another in five minutes, in man. With large doses animals utter a loud cry, fall, and pass at once into convulsions, which soon terminate in paralysis and coma

Tobacco Smoke consists of aqueous vapor, nicotine, free carbon soot in minute particles, and if it be passed through a strong solution of potassium hydrate, and afterward through dilute sulphuric acid, the KOH separates CO_2, CO, acetic, formic, butyric, valeric, and other acids, including a trace of prussic acid, with creosote and some hydrocarbons. The H_2SO_4 fixes ammonia and a series of oily bases parallel to the aniline series. Of these pyridine, C_5H_5N is the lightest, and viridine, $C_{12}H_{19}N$ is the heaviest (Eulenberg and Vohl). The former is more abundant in pipe tobacco, the latter in cigar smoke. Collidine is formed from cigars when smoked with free access of air, and it is far less active than pyridine. These various bases are not all formed in ordinary smoking, for a more rapid and complete combustion is required to decompose the resin into new products. Dry distillation yields a volatile empyreumatic oil ("oil of tobacco") which collects in old pipes and, if inhaled, gives a sense of oppression, and an unpleasant odor to the breath. The odor of "stale" tobacco which clings to clothing and to smoking-rooms, and which is exhaled by the skin, is due to this oil.

In common combustion the nicotine and empyreumatic oil are always developed and inhaled, and the effects of smoking are due to them.

Prevalence.—It is impossible to estimate the number of cases of the tobacco habit. Every physician repeatedly encounters patients with whom he must restrain or interdict the use of tobacco. Laymen generally acquire for themselves a knowledge of the "poison limit" of tobacco, and after one or two experiences in slightly overstepping, learn to avoid it. Tobacco, however, in common with other stimulants and with narcotics, often enslaves the user to a degree which is wholly unsuspected, until through some reason it is suddenly withheld, when the craving for it becomes intolerable. The symptoms of tobacco poisoning from excessive smoking are so well understood by laymen, and for the most part so easily recognized by them, that they can usually control them without resorting to a physician's aid. The physician has therefore to deal chiefly with, first, those cases in which the habit has so undermined the will power as to make the patient a helpless victim of grave functional disorder; and secondly, with milder cases in which the symptoms are obscure, or the concurrence of cardiac or other disease renders the use of tobacco in any quantity most deleterious. Attempts have been made by Anti-Tobacco Societies to summarize statistics regarding the prevalence of the tobacco habit in its various degrees. It is customary in hospitals to refer to it in the case histories. But for the reasons above given, it is seen that such statistics are often useless, and they may be even harmful in exaggeration. A few figures from the Report on Tobacco of the U. S. Census of 1880, will give a better idea of its widespread use. In 1880, there were made in the United States alone over two billion cigars, over four hundred million cigarettes, and over one hundred and thirty-six million pounds of "manufactured tobacco," *i.e.*, tobacco prepared for smoking in pipes and for chewing. There were 638,841 acres under tobacco cultivation, producing 472,661,158 pounds, and attempts were being made in every State and nearly every Territory to cultivate it. The value of tobacco exported yearly from the United States varies between twenty-five and forty-five million dollars.

It is futile to attempt to compute the total number of those who use tobacco in the community. Many who would smoke are deterred by the expense involved, or by chronic maladies, or through fear of yielding themselves uncontrollably to the "Tobacco Habit." In some countries, particularly in the East, nearly every adult male smokes, and many women do so also. In the United States, about all that can be said is that the majority of men, and especially a large majority of the male laboring population, use tobacco in one or other form. Its use among native American women is almost unknown (except among the lowest classes in the South), and wholly unknown among the best classes of society. Indian women and many foreign laboring women, especially the Irish, make occasional use of a pipe. Cases of tobacco-poisoning among women are therefore extremely rare.

The extent to which the tobacco habit (in its general sense) prevails among all civilized and many uncivilized peoples, supplies an easy means for supporting governments by taxation. In England and Ireland attempts were early made to cultivate tobacco, but this has been prohibited by law, in order to enable the government to derive a more certain income by taxation of the imported article. In France there exists a government monopoly of the sale of tobacco, which amounts to 300,000,000 francs per annum. In the United States, in 1885, the receipts for internal revenue, from the tobacco tax alone, amounted to $26,407,088. The North American Indians attach great formality to the smoking of tobacco upon all state occasions, and the "pipe of peace" has become a universal emblem.

Influence of Different Forms of Tobacco—Cigars.—Nearly one-half of all the tobacco grown is made into cigars. They vary greatly in quality and strength, and therefore the effects produced by them cannot be classed as especially differing from other forms of tobacco. Probably a mild, light, good cigar is the least likely, of all the kinds of tobacco, to produce ill effects. Partly smoked cigars which have been relighted, are more bitter in flavor, and the nearer the butt, the stronger the effect produced.

Pipe Smoking.—Many smokers find that they can smoke pipes with less injury than cigars. Much, however, depends upon the mode of use. The pipe-stem should be long enough to cool the smoke, and the bowl should be made of some porous material, like meeramount, with a small reservoir beneath it. The reservoir absorbs the nicotine in products somewhat (which cause it), and the reservoir collects an oily material, one or two drops of which, if worked in through a dirty pipe and taken into the stomach, produce most violent toxic effects. Mild tobacco should be used, and the pipe kept carefully cleaned. In both pipe and cigar smoking the last portion of tobacco smoked is the strongest, because of the absorption by it of some of the products of earlier combustion.

Cigarettes are, upon the whole, the most injurious form of tobacco. Not, however, because they are at all harmful if smoked in moderation, but because they are particularly affected by the youth of the country. Small boys, even under the age of puberty, are sometimes seen smoking them, and youths of sixteen to twenty years are very apt to smoke them to the detriment of their health. Many men actively employed have the leisure for only one or two cigars a day, but they smoke cigarettes in excess because, if interrupted, it is easy and inexpensive to light a fresh one. In this way the taste for tobacco is greatly fostered, until it becomes an abnormal craving. Cigarettes are made of all grades of tobacco, but they are usually inferior to cigars. The best are rolled by machinery, which secures perfect cleanliness, and they should be covered with good French linen paper of delicate texture. There is no such thing as "rice paper" used, as is claimed, for wrappers. The smoke of inferior grades of paper is somewhat irritant to the respiratory mucous membrane, but it is not otherwise especially poisonous. Many prefer to roll their own cigarettes to insure better qualities of tobacco and of paper. A certain number of cigarettes are rolled in tobacco leaves to obviate the objections raised against paper, but they are less popular. The practice of inhaling cigarette smoke, that is, attempting to draw it into the bronchi, retaining it as long as possible, and exhaling it through the nose or mouth, is highly pernicious.

Chewing Tobacco produces constitutional effects similar to those observed from smoking, but it occasions far less local irritation. It is very often the cause of dyspepsia.

Snuff is prepared by rubbing dry tobacco leaves to a fine powder in a mortar. It is then flavored by various aromatics, and is used in the nose by inhalation. In some localities it is placed directly on the palate by a wooden spoon, and the process is called "dipping" (Basiger). Snuff was first introduced to civilization by the Spanish. Of late years Scotch snuff is the favorite. A century ago, and even early in the present century, the habit of snuff-taking was very prevalent in good society among both sexes. Much formality and exchange of courtesy attended its use, and lavish expenditure was made upon jewelled snuff-boxes. The snuff habit rarely produces the neurotic symptoms acquired from smoking and chewing, but it tends to deform the nose by causing congestion of the Schneiderian membrane, and dilatation of the superficial capillaries, and the particles of tobacco dust which find their way into the upper air-passages are highly injurious irritants. The reflex nasal irritation stimulates the cerebral circulation, produces a feeling of comfort, and enables one to think more clearly: it "clears the head" (Brunton). The use of snuff in polite society is now obsolete in America, and almost entirely so in European countries. A comparatively small amount is sold annually for use among the poorer classes.

Tobacco has been used medicinally in the form of fumigations, stupes, and as an infusion or smoke injected per rectum for the purpose of killing intestinal worms, (ascaris and oxyurides). Before the introduction of anæsthetics it was employed as an enema to relax spasm of the muscles during surgical operations, such as reduction of hernias or dislocations. None of these usages are now justifiable, for the drug has several times caused death. Thirty grains by enema have been fatal (Copeland). Tobacco diminishes the venereal appetite when used as a drug, and checks chordee and priapism. It has also been used to promote diuresis in dropsy. It has been used in tetanus, and as an antidote in strychnine poisoning (Haughton). Spasmodic asthma has been relieved by inhaling tobacco (Trousseau) but its action is unreliable. There are no officinal preparations of tobacco. Tobacco leaves have also been applied to the skin as a poultice, and the oil as an ointment for various ailments, such as erysipelas, scabies, gout, etc. Soldiers have been known to apply them in the axilla to produce vomiting and other constitutional effects, in order to escape from duty. Several deaths have occurred from application of tobacco to the abraded skin (Bürger).

It has long been a popular idea that tobacco smoke was a germicide, and therefore an antidote for contagious diseases. Professor Tassinari, of Pisa, has lately shown that tobacco smoke does retard the development of certain bacilli, and prevents the growth of others, especially those of cholera and typhus fever.

Adulteration of tobacco, and especially of cigarettes, with opium and other deleterious ingredients, is frequently assigned as a potent cause of the ill effects of excessive smoking. It is claimed that cigar butts are collected and ground for use as cigarettes and pipe tobacco. In England there is far more adulteration of tobacco than elsewhere, and stringent laws have been enacted to suppress it. In the United States, although much inferior tobacco is sold, it is probably very seldom adulterated, for the simple reason that it is far cheaper to use more tobacco than to put in foreign substances. One stale cigar stump added to a few pounds of smoking tobacco so destroys the flavor, as to require relatively great expense to make it palatable again. It is well known that inferior grades of tobacco are flavored with liquorice to disguise the bitter taste, and that syrups and pure glycerine are added in small amounts for the same reason, and also to maintain a proper degree of moisture; but these substances are not to be regarded as adulterants, and they are certainly not injurious to health.

Effect of Tobacco upon the System. Circulation.—In almost all cases of the tobacco habit the heart action is functionally affected. Long-continued over-excitement of the heart and disturbance of its rhythm may be predisposing causes of cardiac hypertrophy, dilatation, and valvular insufficiency. In the milder cases the heart action becomes irregular only for a little while after each use of tobacco, and is normal in the intervals of smoking. In other cases the patient suffers from palpitation whenever the least exertion or excitement stimulates the heart, and in the worst cases the heart rhythm becomes constantly irregular; every fourth or fifth beat may be omitted or very feeble, and the pulse-rate as a whole may be increased fifteen or twenty, or even more, above the normal. The patient may be annoyed by the sensation of his heart-beats, and his attention being directed to his pulse, he is apt to increase the palpitation by nervous anxiety. Sometimes the pulse beats at the normal rate per minute, but there is irregularity in the force or in the succession of beats. Bruits are rare, but they may occur as a result of (1), altered tension of the heart muscle or valves; (2) altered force of impact of the heart against the lungs and chest wall; (3) anæmia due to general debility. They are purely functional, and disappear with improvement in the heart action.

Attacks of angina pectoris have been attributed to the tobacco habit. Such cases are rare, although patients often complain of precordial "oppression," dull pains, etc., probably the result of dyspepsia.

If tobacco is well borne, and if used in moderation, it has a tonic effect upon the circulation, increasing slightly both the frequency and the force of the cardiac pulsation, and, therefore, raising temporarily the arterial blood-pressure. In larger doses the pressure falls considerably.

The Blood may become anæmic in the course of the tobacco habit, but this is due rather to impairment of digestion and of the general health than to any specific action. In cases of fatal acute tobacco poisoning the blood does not readily coagulate after death. The same is true of many poisons. Crenated red corpuscles are found in abundance (Banfield), and the hæmoglobin is diminished (Richardson). The blood absorbs many of the ingredients of tobacco with great rapidity, and distributes them so as to quickly produce constitutional effects.

Alimentary Canal.—The mouth, tongue, and fauces usually become dry, or at least feel so to the patient, although abundant watery saliva may be secreted. Their mucous membrane becomes congested. In bad cases of the habit from pipe smoking the heat of the pipe, combined with the irritation of the ammonia, nicotine, etc., may produce ulceration of the mucous membrane of the lips, gums, or tongue adjacent to the pipe-stem. The mouth may become lop-sided from continually carrying a pipe or "quid" upon one side. Rarely, syphilis has been transmitted by smoking pipes used by syphilitic persons, or cigars which have been moistened by rolling their wrappers in the mouth. In this way inoculation occurs through any abrasion of the mucous membrane of the mouth.

The tongue may be heavily coated as a result of dyspepsia, or it may be dry and red. Not infrequently, after first smoking two or three pipes, the tongue feels exceedingly dry, and there is a sharp burning pain at the tip. This is due rather to the ammonia evolved with the smoke than to its heat. The tongue soon becomes inured to this in habitual smokers.

Carcinoma of the mouth and throat has often been attributed to smoking. Certainly smoking affords no immunity from it, but the worst cases of tobacco habit may occur without it, and there is no scientific ground for the belief that smoking, *per se*, produces cancer. It is, however, true, with regard to epithelioma of the mouth, that when it occurs in persons having a decided tobacco habit it is prone to affect the lower lip, and the side of it where the pipe or cigar commonly presses. This is said to be the case especially where a short-stemmed pipe, constantly saturated with nicotine, has been long in use. It is known that where the carcinomatous or epitheliomatous diathesis exists, the disease is often focussed at the site of some constant local irritation or injury. Given, then, a predisposition to epithelioma, and the irritation of smoking may focus the disease in the mouth or throat. It is worthy of note that both the mouth and throat are far more injured by smoking than by chewing. Much smoking leaves a black or brown deposit of carbon on the teeth, and the gums become pale and unduly firm and contracted. Chewing stains the tongue and mucous membrane of the mouth, and the beard if there is careless expectoration. The sense of taste is not impaired by smoking. Great smokers may be good judges of the flavor of wines, but the appetite, especially for sweets, is often, not always, diminished. The fact that tobacco smoke so readily gives constitutional symptoms after inhalation, affords an admirable physiological illustration of absorption by the mucous membranes of the mouth and pharynx. Nicotine is a highly diffusible crystalloid. The flow of *gastric juice* and of *intestinal secretion* is stimulated by tobacco in moderation. *Peristalsis* is decidedly increased at first, but, later, constipation ensues from excessive stimulation. Gastric catarrh may result from excessive smoking.

The Pupils are contracted when tobacco is introduced in the eye, or taken by the stomach. In severe cases of tobacco habit there is an abnormally long retention of images by the sensorium when the eye is withdrawn from them (Richardson). Photophobia, muscæ volitantes, etc., are said to occur. Tinnitus aurium has been noted, probably due to the disturbed circulation.

The sense of smell, unless snuff be used, is little, if at all impaired.

Secretory System.—Constant irritation of any gland tends for a certain time to increase its functional activity, with the effect of producing a more watery ("paralytic") secretion with fewer of the normal solid ingredients. Tobacco affects the salivary glands in this manner. Many persons expectorate a great deal while smoking, and all do so while chewing tobacco. In this way the body loses a large amount of water, thirst is increased, and the composition of the saliva is so altered as to impair its usefulness as a digestive agent. There is an increase in the deposit of tartar (salts of lime) on the teeth. Nicotine, like physostigmine, acts on the peripheral ends of secretory nerves, also on the nerve centres. Section of the chorda tympani therefore greatly diminishes, but does not stop, the secretion. Nicotine is less active in these respects than pilocarpine. The practice of expectorating while smoking is wholly unnecessary. It is claimed by some that the saliva, if swallowed, carries more of the noxious ingredients to the stomach, but the difference effected by expectoration, if any, is very slight.

The *perspiration* is increased by the use of tobacco in excess, and the odor of tobacco is perceived in the skin of persons who, without smoking themselves, have inhaled for some time the atmosphere of a smoking-room. Many cannot smoke even a single cigar without exhaling the odor of tobacco by the skin for several hours. Those having a diminished area for pulmonary exhalation, asthmatics *et al.*, retain this odor for a much longer time (Richardson). Nicotine and the resinous body are eliminated by the kidneys (Biddle). It is said that tobacco has a diuretic action, but the effect is not marked.

Respiratory System.—Habitual smokers almost invariably have more or less congestion of the pharynx. Catarrh and hoarseness are so frequent as to give rise to the name "smoker's sore throat."

The mucous membrane is thickened and engorged; there is profuse watery secretion of the mucous glands, succeeded by dryness, with soreness and exfoliation. Speaking, singing, and swallowing are all interfered with. The tonsils are enlarged, soft, and tender. The chronic laryngitis, and pharyngitis, and post-nasal catarrh are exceedingly rebellious to treatment so long as the habit continues. They are more easily acquired from cigars and cigarettes than from pipes. A cough following a simple cold often remains obstinate until smoking is stopped. Pulmonary lesions are not often to be traced to the tobacco habit; but when they are produced in other ways they are fostered by it. Phthisical patients are especially in need of pure air and of a normal heart-action, and therefore tobacco is injurious. Fortunately, persons having severe pulmonary disease seldom care for tobacco. When tobacco of poor quality is used and inhaled deeply in the bronchi, it may give rise to subacute or chronic bronchitis, or to bronchorrhœa, and the functional weakness of the heart, produced at the same time with impaired digestion, tends to retard recovery. The carbon soot from smoke inhaled discolors the bronchial secretion.

Nerves and Muscles.—Tobacco expends its action upon the peripheral nerves and cord, and does not, except indirectly as the result of severe poisoning, affect the brain. Nicotine, like curare, abolishes first the conductivity of motor nerves, and then of motor paths in the spinal cord, without impairing the response of muscles to direct local irritation. As a result of the failure of the nerves to excite muscular contraction there are weakness, inability to stand, great depression of the respiratory movements, and finally death from failure of the muscles of respiration. The heart may continue beating after the respiration has ceased. Tobacco smoke inhaled by a rabbit through the nostrils, or blown up the nose from a tracheal cannula, arrests breathing in expiration, from irritation of the vapor upon branches of the fifth nerve; but it has no such effect if blown into lungs (Kratschmer).

Methyl and ethyl, derivatives of nicotine, have no paralytic action upon the nerves (Brunton). In the case of a patient, who smoked in one day forty cigarettes and fourteen cigars, paralysis of both legs occurred, with bronchorrhœa (Richardson). All motor depressants act as synergists to tobacco. Brunton claims that the stimulus to mental work derived from smoking comes in great part from the warmth of the smoke, which acts on the sensory nerves of the mouth and reflexly stimulates the vaso-motor centre which dilates the vessels of the brain.

Injurious Effects.—Tobacco in any form is highly injurious to children and youths. It impairs digestion, checks nutrition, stunts the growth, and produces serious nervous disorder. It is said to induce premature puberty. The writer has seen chorea in a child of nine years, with violent exacerbations, caused by the habit of chewing tobacco. In military and naval academies, etc., stringent rules are enforced against the use of tobacco. In Germany its use by youths is prohibited by law, and in several of the United States it is illegal to sell tobacco to any one under sixteen years of age.

It is injurious to those who are subjected to severe mental strain, or severe physical training. Athletes, boating crews, prize-fighters, *et al.*, are obliged to temporarily abstain from tobacco, as are those who are employed in very delicate manual work, such as hand section-cutting for the microscope. It is injurious to those who are of a highly neurotic temperament, or who suffer from either functional or organic affections of the heart and lungs. If sudden abandonment of the use of tobacco causes discomfort, restlessness, and craving, it indicates the degree of influence which it has upon the system. If the odor of tobacco lingers long in the breath or perspiration, it is an indication that the system is saturated with it.

Some forms of tobacco are more harmful than others. Generally only the leaves of the tobacco plant are used, but Latakia (Syrian) tobacco has the buds and flowers added. The dark, rich color of Cavendish is produced by sprinkling the leaves with an infusion made from the midribs, stalks, and other waste parts. They are then fermented a second time, dried, and pressed by machinery into cakes. Cavendish, pig-tail, etc., yield more fluid residue than Turkish tobacco. The latter dries the tongue from excess of ammonia, but upsets digestion less. Cigars which are "good" cause dyspepsia more readily, for nicotine is more readily formed from them. Most men can smoke much more at sea, or in the open air, where elimination is freer, and an extraordinary degree of toleration for tobacco is acquired by many, after long practice.

Lesions of varied character have been attributed to the tobacco habit, such for example as atrophy of the auditory and optic nerves, apoplexy, and the like. Such cases, however, are without foundation.

SYMPTOMS OF A MILD CASE of tobacco poisoning, such as may result from smoking the first cigar, are these: Vertigo, headache, and faintness are soon followed by nausea and an indescribable feeling of oppression in the epigastrium; and general prostration, palpitation, pallor, and possibly dyspnœa and vomiting result. The state of the stomach and the time of day modify these symptoms. Tobacco always has more effect upon an empty stomach and if smoked early in the morning. The ill effects may last for a day or two after the first smoke. If depression occurs at once on attempting to smoke, it is an indication that even the smallest quantity of tobacco is injurious (Anstie).

SYMPTOMS OF SEVERE CASES.—The appetite fails, especially in the morning, the tongue is coated, the bowels constipated, the breath foul, and a train of nervous symptoms follow: restlessness, nightmare, insomnia, hyperæsthesia, irritability of temper, and great hypochondriasis. Attacks of nausea, and even continued vomiting, may occur. The emesis resembles that produced by antimony in the depression which follows. In the worst cases there is malnutrition, loss of weight, the skin has a sallow, yellowish hue, it is cold and bathed in profuse perspiration; often violent cramps and colicky pains accompany the constipation; there are tremors, decided muscular weakness, inability to exert the mind. The throat is congested and sore, the mouth feels parched, the tongue burns, and hot or acid foods increase the discomfort. Rarely there are superficial ulcers in the mouth. There is increased vertigo, and there may be disturbed vision. There may be slight fall of temperature owing to the perspiration and the general depression.

TREATMENT OF MILD CASES.—Temporary suspension or limitation of the use of tobacco is frequently all that is required in mild cases of functional disorder produced by its use in excess. Frequently patients need no further warning than the experience they have had. All cases, however mild, should be carefully examined as to the coexistence of possible causes or preliminary organic disease, anæmia, etc.

TREATMENT OF SEVERE CASES.—It is best to interdict entirely the use of tobacco for several months or even years. This is usually easier for the patient after the first day or two, than any attempt to abandon the habit by lysis. The diet should be regulated, the digestion aided by appropriate medicaments, and the functions of the liver stimulated. Blood and nerve tonics, as iron, strychnine, arsenic, etc., are particularly indicated. The palpitations are best controlled by heart tonics, such as digitalis, strophanthus, caffeine, cactus, and convallaria. In the experience of the writer the combination of two or more such tonics in moderate doses (*e.g.*, strophanthus with digitalis or with caffeine) is far more prompt in controlling the great irritability of the heart than is either remedy used alone. The insomnia and restlessness, which are often prominent symptoms, are frequently cured through the general improvement in circulation and digestion which follows the treatment above suggested, and without recourse to anodynes. The latter are to be avoided, if possible, because of the ease with which one "habit" may be grafted upon another in any crisis of the nervous system. Over-indulgence in strong black coffee often complicates the tobacco habit. The physician should always bear in mind the frequency with which alcoholism is associated with the tobacco habit. There is danger that in suddenly withdrawing the additional stimulus of tobacco, the craving for drink may be exaggerated, and precautions should always be taken to control both habits together.

TREATMENT OF THE WORST CASES.—In the gravest form of chronic tobacco poisoning, if the drug be suddenly withheld entirely, there may be some danger of collapse from withdrawal of the accustomed stimulus to the nerve centres, as occurs similarly in the opium habit. Fatal cases resulting from the sudden deprivation of tobacco have not been recorded. The worst cases require active treatment by means of diffusible cardiac stimulants, application of warmth, proper nourishment, etc., to guard against collapse.

TREATMENT OF ACUTE TOBACCO POISONING.—There is no definite poisonous dose. There is no reliable chemical antidote. If the drug has been swallowed, evacuate the stomach, give tannin, and observe the general rules for alkaloidal poisoning and the prevention of collapse by heat, friction, artificial respiration, and cardiac stimulation. Acute and even fatal poisoning sometimes occurs when habitual smokers on a wager smoke sixteen to twenty pipes or cigars at a sitting. Gmelin reports two such cases. In these cases very prompt treatment is necessary. Strychnine and iodides have been given as antidotes, but with doubtful benefit. Ergot, digitalis, alcohol, atropine, and ammonia antagonize the effect upon the heart and circulation.

THE HISTORY of the use of tobacco is remarkable for the violent opposition which attended its introduction and the first century of its use in Europe. James I. of England wrote a tirade against it, and Pope Urban VIII. a bull. Its use was prohibited by law in the seventeenth century in Turkey and Persia—countries where the habit is now almost universal. The literature of satire and denunciation against smoking, and more especially against the dirty habits of chewing and snuff-taking, would fill many volumes. Yet to-day there is no other one article of greater value than tobacco (unless it be alcohol) to nations as a source of governmental revenue, and the active opposition to its use is confined to a few anti-tobacco societies and an occasional enthusiast. It is difficult to believe that the use of tobacco, or the tobacco habit, will ever be abandoned, or that it will ever become less prevalent. In regard to the question so often asked every physician, "*Is smoking injurious?*" no brief answer can be truthfully given, but the following summary of the facts may be stated:

1. Both individuals and nations have attained the highest intellectual and physical development without the use of tobacco in any form.

II. Tobacco is in nowise essential for the welfare and progress of mankind.

III. Tobacco, like alcohol, is positively injurious: 1, to the young; 2, to those suffering from certain maladies, notably cardiac and pulmonary diseases; 3, to those who have a marked idiosyncrasy against it, or who have a highly neurotic diathesis; 4, to those who have not sufficient will-power and force of character to enable them to restrict its use properly; 5, to everyone, if used to great excess.

IV Many inveterate smokers have lived to be over ninety or even one hundred years of age, without having their health affected by the use of tobacco.

V. All nations and all races ascribe value to the use of tobacco as a sedative for the relief of fatigue and ennui. Smoked in moderation after meals, it stimulates secretion, aids digestion, and increases peristalsis.

Many find in it a soothing influence, it promotes reverie, overcomes weariness, and as a moderate stimulant, in a limited degree, it takes the place of scanty food (like coca, Anstie).

VI. Those who have passed middle life, and whose physical, emotional, or intellectual faculties are overburdened with the activities of modern civilization, often find that tobacco favors mental and physical calm, and counteracts nervousness and exhaustion.

VII. An enormous number of persons do use tobacco constantly without any ill effects whatever; although the tobacco habit is seductive, and, once thoroughly established, it tends to grow beyond easy control.

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William Gilman Thompson.

TOES, DEFORMITIES OF THE. Many of the deformities to which the toes are liable are similar in their nature to those of the fingers.

Syndactylism in the lower extremity is less rare than is the same affection in the hand, and it is not uncommon to see two of the toes united as far as the first interphalangeal joint. As, however, the deformity does not seem to interfere in any way with the function of the foot, and as it is concealed by the shoe, it seldom calls for treatment. If in any case it be deemed advisable to release the toes it may be accomplished in the same manner as the separation of webbed fingers (see Vol. III., p. 498).

Polydactylism in the foot is frequently seen in connection with the same deformity of the hand. Amputation of the extra digits is usually needful to restore the shape of the foot, though this measure is not as imperative here as it is in the upper extremity.

Clubbing of the toes is sometimes observed along with a similar condition of the fingers in phthisis and other diseases of the thoracic organs. As the condition is merely an indication of defective hæmatosis, it calls for no special treatment.

The other non-painful deformities of the toes need no special mention, since they cause no inconvenience to the patient and seldom are brought to the notice of the surgeon. It is otherwise, however, with certain other affections which, though seemingly insignificant, are often the cause of much suffering and inconvenience, and may even interfere so seriously with locomotion that the patient becomes practically bedridden. The gouty and rheumatic deformities of the toes, as also hallux valgus and ingrowing toe-nail, have been discussed in other portions of this work, and we have to consider here only that condition known as hammer-toe.

HAMMER-TOE (Fr., *orteil en marteau*; Ger., *Zehenverkrümmung*) is an affection characterized by a permanent flexion at the first interphalangeal articulation of one or more of the toes. The second toe is the one most commonly, though not exclusively, affected. Not infrequently the deformity is seen in both feet. The third phalanx may be extended or flexed, or in a line with the second, and some French writers have accordingly distinguished three forms, named, from the fancied shape of the toe, respectively, **Z** form, **C**-form, and **L**-form. The affected joint is seldom actually anchylosed, except occasionally in the later stages, but it is simply restricted in extension; additional flexion is not interfered with, but it is impossible to straighten the toe. Not infrequently, when the deformity has existed for some time, there is a subluxation of the second phalanx upon the first.

The affection is usually the cause of a great deal of annoyance, and often of acute suffering. The impact of the tip of the toe on the sole of the shoe in walking causes pain, and sometimes an acute subungual inflammation. The pressure of the shoe upon the prominent angle formed by the flexion of the digit produces considerable irritation, which leads in time to the formation of a very troublesome corn. Sometimes a bursa develops at this point and then becomes inflamed, resulting in the production of a bunion. This may subsequently suppurate and give rise to the formation of an obstinate ulcer. Dubreuil has described this latter condition under the name of *mal dorsal des orteils*, and regards it as analogous to perforating ulcer of the foot. If neglected, this ulcer may increase in depth, and finally open into the joint, setting up an arthritis with exfoliation of the cartilage and necrosis of the phalanges.

The causation of hammer-toe is obscure. It has been attributed to ill-fitting shoes which are either too narrow or too short, and in support of this view it is stated that the deformity is never seen among Eastern peoples who do not wear European shoes. A fact which would seem to argue against this theory is that men are somewhat more frequently affected than women, although the latter are more prone to confine their feet in closely fitting shoes. It is probable that defective shoes are seldom the exciting cause of the deformity, though they undoubtedly play an important rôle in the production of the later troubles which have been described above. In many cases there seems to be an hereditary predisposition to hammer-toe, the condition being frequently present in several members of the same family. The deformity appears usually during childhood, and has even been seen in infants, and is, perhaps, due to some vice of development.

According to Shattock, who bases his views upon the results of dissection in several cases of recently amputated hammer-toe, the flexion of the toe is due to a shortening of the lateral ligaments, and not, as has been supposed by some, to a contraction of the flexor tendons or of the plantar fascia. After the deformity has existed for some time, changes take place in the articular ends of the bone similar to those occurring in knock-knee and lateral curvature of the spine. There is a wearing away of the lower half due to pressure, and an overgrowth of the upper half from which the normal pressure has been removed. When subluxation has occurred early these alterations are not so marked. When these changes have taken place, little can be hoped for from any measure except resection of the joint.

In the treatment of hammer toe little can be effected in the majority of cases by mechanical apparatus, and the same may be said of massage, though either of these measures may be useful in the earliest stages of the deformity. Mr. William Adams, who looks upon the condition as one of contraction of the lateral ligaments, advises and practises the subcutaneous division of these ligaments. After the operation the toe is bandaged to a light metal splint for some weeks to prevent a return of the flexion. Terrier makes a V-shaped resection of the joint, removing a small wedge from each articular surface, excising at the same time the callosity or bunion that has formed on the convexity of the joint. Anderson performs a somewhat similar operation, resecting the articular surface of the first phalanx. In the severest cases, in which the deformity has existed for a considerable length of time and inflammatory changes have taken place in the joint and peri-articular tissues, amputation of the toe is often the only recourse left to the surgeon. This operation, indeed, is recommended by some in all except the mildest cases, but, in view of the successful results of resection and of syndesmotomy, so radical a measure as amputation seems hardly called for.

HALLUX FLEXUS (hallux rigidus, hallux dolorosus). This is a condition allied to, and perhaps in many instances identical with, hammer-toe, in which there is flexion of the first phalanx of the great toe. The second phalanx is usually extended upon the first, and there is more or less rigidity of the metatarso-phalangeal joint. Walking is more or less painful, and the patient generally rests his weight upon the outer edge of the foot. The occurrence of the deformity is variously attributed to compression from an ill-fitting shoe, to traumatism (as from stubbing the toes), and to a breaking down of the plantar arch. Possibly any one of these factors is sufficient to produce the deformity, and in some cases it may result from the combined action of all of them. Doubtless it is often nothing else than hammer-toe affecting this digit instead of its next neighbor. All the cases hitherto reported have been in men, but this fact is probably without significance, as the number of recorded cases is not large. The only cases which the writer has seen, two in number, were in young women.

When the deformity is secondary to flat foot it will disappear upon the restoration of the plantar arch. In other cases, if massage, splints, and mild measures fail, resection will be indicated. *Thomas L. Stedman.*

UNDERWOOD SPRING, Falmouth-Fore-Side, Me., on the shore of Casco Bay, six miles from Portland.

This water is remarkable as being one of the purest known.

ANALYSIS.—One U. S. gallon contains (Bartlett):

Sodium chloride	[illegible]
Silica	[illegible]
Lime carbonate	[illegible]
Magnesium carbonate	[illegible]
Potassium sulphate	[illegible]
Organic matter	[illegible]
Total	[illegible]

A glance at the above table reveals this striking feature. Every precaution has been taken to guard the well against contamination. There are as yet no accommodations for guests, though the exceeding beauty of the locality and the unquestioned value of the water should render this spot invaluable as a health-resort. The supply seems inexhaustible; 20,000 gallons are used per day for commercial purposes, while many times that amount are allowed to run to waste.

The Indians appreciated this spring, as is revealed by the presence of huge mounds of partially burned shells in the immediate vicinity.

The well is only a few hundred feet from the waters of Casco Bay, which, with its many islands and rock-bound shore, offers a constant feast in the way of picturesque surroundings.

Its purity renders this water the best solvent for the contents of mucous cavities. It is readily absorbed and excreted, thus perfectly performing that office for which pure water only is adapted.

Therapeutically it is indicated in chronic catarrhal diseases of the alimentary canal and urinary system, rheumatism, and gout. *George B. Fowler.*

URETERS. Simple and uncomplicated disease of these tubes, outside of their pelves, is quite rare.

PYELITIS.—The most important diseased condition of the ureters is that which implicates chiefly their expanded and superior portion. It is an inflammatory or catarrhal process of the pelves of the kidneys and of their calices. It may attack one or both organs at a time.

Etiology.—Sometimes, though rarely, it may occur after exposure to cold, but its most frequent cause is the irritation of renal calculi in the pelvis, or some obstruction in the urethra, bladder, or ureter itself. When the urine is acrid or unduly acid, it excites a hypersecretion of an alkaline mucus from the muciparous glands of the pelves of the kidneys, and the presence of this mucus, together with the unduly acid urine, acts as a constant irritant to the mucous membrane of the renal pelves. In this way there is developed, first, a catarrhal condition of the mucous membrane, which is shown in the discharge of acid urine containing pus. Later, the hyperacidity is overcome by the abundant hypersecretion of mucus, a true inflammatory process is excited, and all the symptoms of a typical pyelitis are finally developed.

This is the mode of development of many of the apparently idiopathic cases. A mild form is sometimes excited by any of the varied forms of renal disease, and occasionally it occurs during pregnancy. It may also result from cystitis, ureteritis, gonorrhœal urethritis, and, in fact, from any inflammatory conditions of the urinary tract, by an extension of the same to the pelvis. With gonorrhœa, the inflammatory process in the renal pelves may develop suddenly, without any apparent involvement of the intervening portion of the urinary tract. Pyelitis may be excited by turpentine, cantharides, squills, and the many forms of irritating balsams, resins, etc., as well as by all acrid substances excreted by the kidneys.

A mild form of this disease is sometimes developed in the typhoid stage of cholera, in typhus fever, diphtheria, and in any of the exanthemata. In these instances the superacidity of the urine and increased amount of effete material eliminated, together with the general deterioration in the nutritive conditions, both general and local, are important factors in exciting the pyelitic inflammation.

A hæmorrhagic variety has been described by some writers, in which there are frequent, and sometimes extensive, hæmorrhages into the renal pelves. This condition occurs in connection with scurvy, purpura hæmorrhagica, pernicious anæmia, and chronic syphilis.

Pathological Anatomy.—The mucous membrane is very much congested and dotted with ecchymotic extravasations, and in places the epithelial surface is completely destroyed. In the most acute stage there is little or no discharge, but as the disease advances and becomes more chronic a muco-purulent secretion occurs and the membrane is relaxed and swollen. As the inflammation advances, the pelves and infundibula become enlarged and their walls thickened; the color of the mucous membrane changes to a grayish-white or slate color, and its surface is traversed by delicate capillaries. Should there be much irritation, ulceration is liable to take place, which may cause rupture of the wall and extravasation of the urine into the surrounding tissue, the peritoneal cavity, or into some of the surrounding organs, inflammation having been excited and previous adhesions formed.

The walls of the pelves may be very much distended by the retained urine and accumulated pus, and the kidneys may undergo atrophy, as in hydronephrosis. Occasionally the fluid may be entirely absorbed, the pelvis of one kidney becoming contracted into a hard capsule around its own inspissated contents, while the ureter is converted into a fibrous cord, its lumen having been obliterated. In certain cases where the inflammation has been very severe, a fibro-plastic exudation is thrown out upon the surface of the mucous membrane; this has been termed a diphtheritic pyelitis.

Symptoms.—In studying the symptoms it must always be remembered that those of the pyelitis are often masked by those due to the exciting cause. The disease usually begins, however, with a chill, sometimes a series of rigors, followed by a rise of temperature of about three degrees Fahrenheit, pain in the back, increased on pressure, and often radiating down along the course of the ureter. There is often nausea and vomiting, together with a continual desire to micturate, and pain on attempting to do so. As the disease progresses and becomes more chronic, the lassitude from which the patients suffer increases. Hectic is finally developed, and death ensues, either from exhaustion or from a form of septicæmia, or from the combined action of both.

In those cases which are due to a renal calculus, the pain in the loins is the most prominent symptom.

Another quite diagnostic symptom is the alternating discharge of clear or normal urine, and of urine charged with pus.

Urinary Examination.—The urine is usually increased in quantity, owing, perhaps, to the moderate hyperæmia of the kidneys always associated with this disease. The specific gravity is somewhat above normal, from 1.025 to 1.030, and the reaction is alkaline. Under the microscope the urine is found to contain blood, pus, and epithelial cells.

Great stress has been laid upon the character of the epithelial corpuscles in the urine and their diagnostic significance in reference to pyelitis. It, however, is well known that there is a great variety in the form of the epithelial elements found in the urine, some of which are derived from the urinary tract, and others from the generative organs, while a smaller number may come from the air-passages, the mouth, or the skin. But, of all these, the variety known as flat or pavement epithelium, the tailed cells, and the small angular cells commonly called "renal," have given rise to the most discussion.

Naturally, epithelial cells from the urinary tract are found in either sex. On the other hand, the urine of the female is almost invariably said to contain a peculiar sort of large and angular cells that have been regarded as peculiar to the sex. But all varieties, sizes, and forms of epithelial cells may come from the bladder, the ciliated form excepted. The structure of the mucous membrane of the bladder distinctly explains this, because it is divisible into three separate layers. The innermost, or deepest, is composed of several rows of small cells, varying in size and shape, but usually cuboidal or round in outline. When these cells are shed rapidly they increase in size and have a more irregular form, especially in catarrhal conditions or where the mucous membrane is inflamed in any way. The intermediate plane is made up of a single or in part double layer of pyriform cells. Their tail-like prolongations are either single or double, but in the majority of instances single, and fitted in between the epithelial cells of the deeper layer. Their round ends fit into depressions in the inferior face of the superficial cells.

The third or outer layer is composed of a form of flattened cells called transitional. These cells are made up of large masses of protoplasm which usually appears to have two or more nuclei, but often this phenomenon is an optical illusion, and one at least of the apparent nuclei is produced by the fossa on their lower surface, where it rests upon the underlying corpuscles. In case of an ordinary catarrhal condition or inflammation, the epithelial membrane may be cast off in separate layers, or with its three layers adhering together, and appearing as such under the microscope.

A careful examination of the mucous membrane of the renal pelves, of the ureters, of the bladder, and of the vagina, demonstrates that in all these regions the membrane is composed of three layers of cells similar to those found in the urine as illustrated by Figs. 5097 and 5098, and from the bladder, ureters, renal pelves, and vagina, as in Fig. 5099. Although the epithelial cells known as flat, or vaginal, do not concern us directly in the study of pyelitis, they do indirectly in giving a more complete knowledge of all the kinds of epithelial cells that may be found in the urine, and the varying circumstances under which they may be present. A few words, therefore, in relation to them is quite admissible at this point.

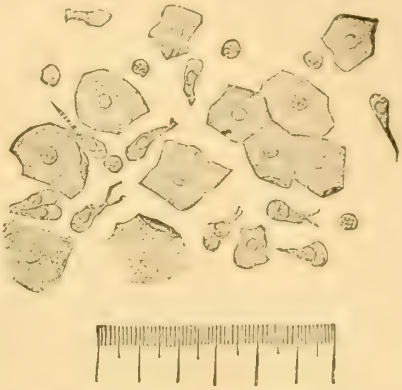

FIG. 5097.—Cells found in Urine. Each division of the scale equals 0.0033 mm., or 3.3 μ, roughly, 3⅓ μ. The large flat cells average, probably, from 40 to 55 or 60 μ in their greatest diameter. Fifty cells, measured carefully by the author, averaged 49 μ in their greatest diameter, and 37 μ in the diameter at right angles to the long one.

The so-called vaginal epithelial cells have been found, on investigation, to be quite as likely to come from the female bladder, and even from the ureters or the pelves of the kidneys, as from the vagina. There is also another quite interesting point of medico-legal interest in connection with these cells, some alleging that they are always absent in the virgin. The writer's attention was especially called to this subject when making a necropsy upon a female patient, aged eighteen, who had died twenty-four hours after a fracture of the skull. When the kidneys were examined they unexpectedly gave every evidence of a chronic parenchymatous metamorphosis. The urine was examined to see if it contained evidence of the renal lesion, which it did in every particular. It was also found to contain an abundance of large flat cells identical with those commonly called vaginal, and single and

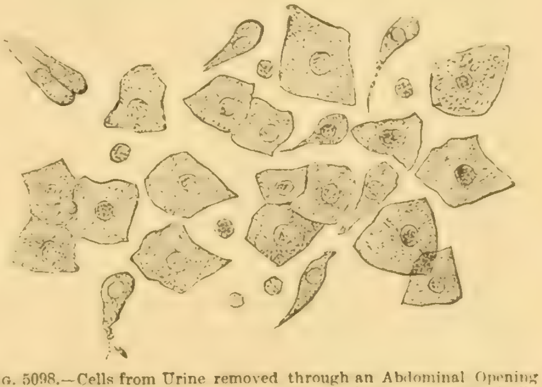

FIG. 5098.—Cells from Urine removed through an Abdominal Opening into the Bladder. The measurements for this figure are practically the same as in Fig. 5097.

bifid-tailed cells also were abundant. In this case the urine was not withdrawn through the urethra, but the bladder, which happened to be distended, was opened from the abdominal cavity, and its contents were withdrawn through a clean syringe. Further, there was no evidence of the existence of an acute or chronic inflammation of the pelves of the kidneys. Excluding the vagina, and tracing the origin of these flat cells to the bladder, it becomes necessary to explain the fact of their frequency in the female and rarity in the male; this can be done as follows: From the loose attachment of the bladder to the movable anterior wall of the vagina there is of necessity greater mobility in the female than in the male. The frequent motion and tendency to pouching of the trigonum vesicæ, and the more frequent over-distention in the female, naturally tend to excite a mild catarrh, which damages the epithelial cells, loosens their attachments, and easily accounts for their frequent and abundant desquamation. On the other hand, the firm attachments of the male bladder to the surrounding tissue, and its less mobility and distensibility, tend to hold the epithelial cells in their proper relations. In either sex, when this desquamation does occur from the bladder only, it is quite clear from the accompanying cuts that not only flat epithelial cells, but single and bifid-tailed epithelial cells, will also be found in goodly numbers.

This point of depending upon the tailed cells or any special form as diagnostic of pyelitis, appears to be quite conclusively overthrown by the following observations, made by Dr. Creedon, now of Globe Village, Mass., while working in the laboratory of Professor Satterthwaite. He prepared with great care specimens of the epithelial cells from the different portions of the urethra, bladder, ureters, pelves of the kidneys, and renal tubules. He made accurate measurements and also drawings of the cells removed from the various regions. The result of his researches was, that single and bifid tailed epithelial cells were present throughout the mucous membrane of the urinary tract, from the meatus urinarius to the papillæ of the kidneys. He further found that the renal epithelial cells, and those from the deeper layers of the urinary tract and from the uriniferous tubules of the kidneys, also corresponded exactly in size and shape in all the specimens and in the different regions. Of course, various shapes and sizes existed throughout, but the general average was uniformly the same. This careful observation was strong evidence in favor of the impossibility of locating with certainty the source of any given variety of epithelial cells when found in the urine. These experiments were made upon subjects in whom the membrane was free from any inflammatory process at the time of death. If the membrane examined was the seat of any inflammatory action, the rapid metamorphosis, subdivision, and desquamation of the cells would tend to make the similarity still greater.

In the instance already cited by the writer, the tailed epithelium, both single and bifid, was abundant, but there was no evidence of pyelitis or of any inflammatory condition of the urinary tract at the necropsy. There was, however, catarrh of the bladder. To establish more certainly the close similarity in the shape and size of the epithelial cells in the various regions of the genito-urinary tract, the writer and his assistants made a large number of similar examinations. Specimens were carefully prepared from the pelves of the kidneys, the ureters, the fundus and trigonum of the bladder, and from the vagina. Drawings and measurements were made of the various kinds of cells from the different regions, also of the cells found in the urine taken from the bladder through the catheter at the time when the necropsies were made. In all the different regions and in all the cases examined, the size and shape so closely corresponded that no apparent difference could be made out, as is well illustrated by the drawings (Fig. 5089). The various specimens were also carefully measured, and the figures corresponded. The only variation that could be detected in the flat cells was a slight difference in size, those from the vagina and bladder being a little larger than those from the ureters and pelves of the kidneys.

The middle layers of the vagina contained cells that approached more closely typical spindle-shaped cells than the pyramidal type of the other regions.

The results obtained by Dr. Creedon, together with the writer's observations, are strong proof of the untrustworthiness of the statement of Professor Ebstein in von Ziemssen's "Cyclopædia of Medicine," vol. xv., p. 574, that the occurrence of tailed epithelial cells in purulent urine is the most positive indication that the patient has pyelitis. By reason of the above facts it becomes absolutely impossible to base any positive diagnosis of pyelitis upon anything found in the urine with the microscope. Albumin will always be found on account of the pus.

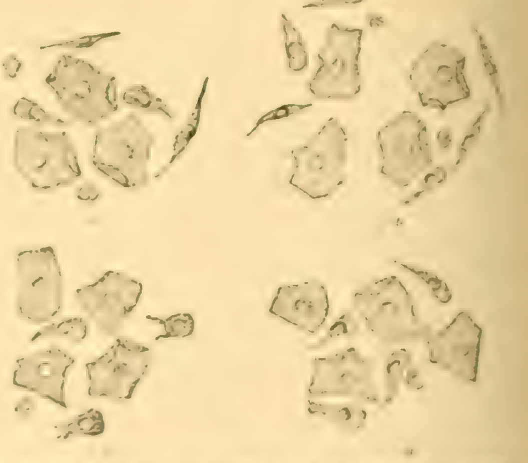
FIG. 5089.—a, Cells from the vagina; b, the six cells on the left came from the trigonum vesicæ, and the six to the right from the fundus of the bladder; c, cells from the ureters; d, cells from the renal pelvis.

In some cases the urine and pus may be retained in the pelvis of one kidney for a time, and the urine excreted by the other kidney will then appear normal.

In other instances the urine is permanently retained in the pelvis of one kidney; under such circumstances there will often be found a pyelonephritic tumor in the lumbar region, which will produce a bulging of the side between the crest of the ilium and the twelfth rib. There will be deep-seated fluctuation, which can be detected upon palpation, with tenderness upon pressure, and dulness upon percussion, except where the tumor is crossed by the colon containing gas. If tapped, a seropurulent fluid may be obtained, but with all the above symptoms the urine may remain normal and free from pus.

A mild form of pyelitis is far more frequent than the severer type just described. It is often mistaken for and treated as a cystic catarrh or inflammation.

This variety is often quite chronic, when it unquestionably acts as an exciting cause for the development of intrinsic renal lesions. Its characteristic symptoms are the passing of pale *acid* urine, which usually has a low specific gravity, and contains albumin and pus corpuscles. The urine from a case of chronic pyelitis contains a fair amount of pus, while the reaction remains strongly acid; in cystitis the urine contains pus in varying quantities, but the reaction is alkaline.

From the study of a large number of these cases this conclusion has been formulated: When the patient has increased micturition, and has to rise several times during the night to empty the bladder, and the urine passed is strongly acid, with a considerable quantity of pus-corpuscles and some albumin, but no casts, the catarrhal or inflammatory condition is located in the pelves of the kidneys.

These cases are frequently kept up by an undue acidity of the urine. This high acidity also prevents the alkaline fermentation that otherwise would occur, and explains the irritability of the bladder, and the symptoms simulating a catarrhal or inflammatory state of this viscus.

In other cases this superacidity induces such a copious discharge of mucus from the pelves of the kidneys, that an alkaline fermentation is speedily developed, and the urine which escapes from the urethra is at all times alkaline in its reaction.

This has led to the supposition that the primary cause was an undue alkalinity of the urine, and when the cases have been treated as such, the results have proved to be unsatisfactory. When, however, the true cause, the superacidity of the urine, is recognized and treatment for it instituted, a rapid disappearance of the alkalinity occurs, and an improvement or complete recovery is soon effected.

The *diagnosis* in many cases of pyelitis is exceedingly difficult to make with certainty. If the patient has, along with the above symptoms, alternating intervals of purulent and clear or normal urine, the diagnosis of pyelitis is pretty certain to be confirmed at the necropsy. This phenomenon occurs in connection with those cases which are due to renal calculi, or plugging of the ureter with mucus or inspissated pus. On the other hand, it should be remembered that this fluctuation is not always present. The continuous discharge of acid urine containing pus, especially in the absence of marked bladder symptoms, is positively diagnostic of pyelitis.

The *prognosis* depends in a great measure, if not wholly, upon the exciting cause. When it is a complication of chronic cystitis, enlarged prostate, urethral stricture, and operations upon the genito-urinary tract, the prognosis is very unfavorable, to say the least. When pyelo-nephrosis occurs the tumor may disappear, the sac be obliterated, and the patient recover, but it ruins one kidney; if this does not take place, and no rupture follows, death may be expected from exhaustion or septic toxæmia. Should the sac rupture, the prognosis will depend upon the seat of the extravasation; if it is into the peritoneal cavity, or the retroperitoneal areolar tissue, death will ensue from shock, peritonitis, or septicæmia; if externally or into the alimentary tract, the patient may, and not infrequently does, recover. If both kidneys are the seat of a pyelitis, the case is almost always certain to terminate fatally, but when only one is implicated there is always a chance for recovery.

Treatment.—At the onset of the disease, wet or dry cups to the loins, followed by warm poultices, should be employed, and morphine should be injected hypodermatically if the pain be very severe and unbearable; considerable care, however, must be exercised in the use of opium in any form, for in some it excites a fatal uræmia. Alkaline and demulcent drinks should be administered freely, as they render the urine less irritating.

The combination of damiana, hyoscyamus, and bicarbonate of potassium is a most valuable mixture not alone in inflammations of the renal pelvis, but in all forms of catarrh and inflammation involving any portion of the mucous membrane of the urinary tract. This statement is especially true in regard to the bladder. For it is quite clear that a large proportion of the inflammatory conditions of this canal, not due to a calculus or some mechanical obstruction, are in a great measure dependent upon a depressed and overworked condition of the lumbar portion of the spinal cord, and to a similar condition of the abdominal sympathetic system, and especially of the hypogastric, renal, and vesical plexuses, in connection with an over-acid condition of the urine.

If we overcome these difficulties, restore the cord and sympathetic system to their normal state, and remove the irritant properties of the urine, the inflamed mucous membrane will, by nature's intrinsic reparative powers, be speedily restored to its normal condition.

The combined use of the fluid extract of damiana and hyoscyamus and bicarbonate of potassium fullfis these three indications, and their administration is usually followed by immediate relief.

The damiana is one of the most powerful tonics to a depressed or overworked spinal cord; while in health it has but little, if any, influence. The so-called antispasmodic action of hyoscyamus is due to its power to stimulate a weakened sympathetic system, and in these cases acts by its stimulating properties, and raises the depressed and irritable hypogastric plexuses to their normal standard and activity. The alkali renders the superacid urine less irritating and more nearly normal in reaction.

The hyoscyamus and potash are not new agents, but the damiana is, and one greatly needed in many of these cases, for they are frequently excited by venereal excesses. Hot baths, especially hip-baths, and perfect rest must be insisted upon. One of the best methods for a medicated sitz-bath is to put a bunch of wormwood in a chamber or other receptacle in a closed water-closet chair, and then pour on it some boiling-hot water, and have the patient sit over the steaming infusion.

If the disease becomes chronic, with the excretion of large quantities of pus, astringents, especially gallic acid, will be found useful, and in all a nutritious nonstimulating diet must be enforced.

In case pyonephrosis makes its appearance, aspiration is the only mode of treatment at first, both to prove the correctness of the diagnosis and to lessen the immediate danger from rupture into some locality, when a fatal result would be almost certain to ensue; later, if the tumor reappears, it may be expedient to make a free and permanent opening through the abdominal wall.

Counter-irritation to the lumbar region, in the form of actual cauterization, is often followed by a great improvement.

As an undue acidity of the urine often exists and keeps up the inflammatory action, it should be regarded as indicating a digestive disturbance which requires attention, in order that the quantity of uric acid produced may be diminished. By a careful attention to this condition, as well as to the local disease, the nutritive powers of the system will be increased, and the amount of irritating excretory products passing out through the urinary tract will be greatly decreased. The accomplishment of these two ends will insure recovery in many instances when all local measures have failed, but when both are judiciously combined a favorable result is almost certain.

In addition to the means already enumerated, the operation of kolpo-uretero-cystotomy,[1] as practised by Dr. Nathan Bozeman, may be successfully carried out in some cases. This operation consists in the establishment of a temporary vesico-vaginal fistula, by cutting through the anterior wall of the vagina into, and through, the posterior wall of the bladder, in such a direction that the superior extremity of the wound will terminate just anterior to the vesical opening of the ureter to be treated. In this way the ureter can be easily catheterized, the pelvis of the kidney drained, and local medication readily applied. By using Dr. Bozeman's utero-vesical drainage support, all the inconveniences from incontinence of the urine will be avoided and the patient will be made perfectly comfortable. As all the discomfort from the vesico-vaginal fistula has been overcome, it can be kept open until the diseased condition of the ureter or renal pelvis has been cured. When the disease of the renal pelvis or that of the ureter has been subdued, the opening between the bladder and vagina should be closed by the ordinary operation commonly employed for vesico-vaginal fistulæ.

RENAL CALCULI.—The condition which stands next in importance to pyelitis is that known as renal calculi.

A renal calculus is a concretion formed in the tubules of the kidneys, or in the renal pelves, by a deposition of one or more of the solid constituents of the urine. Calculi may form at any time during intra- or extra-uterine life.

The precise cause of renal calculi is unknown, and although many theories have been advanced to account for their development, none is entirely satisfactory.

It is known, however, that every calculus has a nucleus of some foreign substance, such as pus, inspissated mucus, blood, pigment granules, or crystals of some sort; often uric acid, as this is the most insoluble substance found in the urine. The uric acid is also very frequently produced in abnormally large amounts. Further, renal calculi are usually composed of uric acid, but other kinds occur, such as those composed of oxalate of lime, phosphate of lime, carbonate of lime, cystine, xanthine, and still others composed of several of these ingredients.

In cases in which there has been a deposition of crystals without the formation of large calculi, the kidneys upon post-mortem section have a streaked appearance, usually of brick-red color, owing to the presence of the uric acid in the tubules. If the concretion be large and yet retained in the substance of the kidney, it becomes the source of much irritation; congestion and inflammation are excited, and often followed by suppuration and abscess; in fact, it acts as a foreign body would elsewhere. If, on the other hand, it passes from the kidney and remains in the pelvis of the organ, it becomes a fruitful source of pyelitis. By blocking up the opening to the ureter it may produce hydronephrosis. In case the calculus becomes large, it may of itself press upon the renal substance and in this way cause marked atrophy of the kidney. Passing from the renal pelvis down to the bladder through the ureter, it may there become the nucleus for the formation of a vesical calculus.

Symptoms.—Renal calculi which are retained in the pelvis of the kidney may increase to a very large size, and even completely destroy the renal substance, without having given rise to any sign of their presence during the life of the patient.

But usually there is pain in the lumbar region, which shoots down the groin, and is aggravated by exercise or any jolting of the body. In the urine blood, pus, epithelial cells, and often crystals, usually of uric acid or oxalate of lime, are discovered. Sometimes a calculus may pass from the pelvis through the ureter to the bladder, and so on out through the urethra, without the patient's knowledge; but, as a rule, the symptoms are painfully severe.

When attacked by renal colic the patient complains of intense shooting pains in the loins, radiating over the hypogastrium and down the inner side of the thighs. The testicle and the scrotum of the affected side are often retracted, and there is sharp pain there, as well as in the head of the penis. In the female the labia are affected in like manner, but women seldom suffer from renal calculi.

There is often nausea and vomiting, the patient is covered with a cold perspiration, the respiration is rapid and shallow, the pulse small, hard, and rapid, with great anxiety of countenance.

An attack may last for a few minutes only, or there may be remissions followed by recurrences, each one appearing to the patient more serious than the one which preceded; but if the calculi become lodged in the ureter, the symptoms gradually subside and hydronephrosis is developed.

Prognosis.—The presence of a renal calculus in the pelvis of the kidney is variable in its consequences. No danger is to be feared so long as complications are not developed. When they occur the prognosis rests upon the nature of the complication, and not upon the presence of the calculus. A fatal result from renal calculi rarely occurs, unless by the induced suppression of urine, secondary to nervous exhaustion excited by nature's efforts to expel the stone.

Treatment.—Under the head of treatment many different ways have been proposed, with the view of dissolving the calculus *in situ*, but none of them has been found reliable. The very great insolubility of uric acid in water renders it almost impossible to pass enough of any safe solvent through the system to dissolve it after it has once been deposited in its crystalline form. Perhaps a hygienic mode of life, by which the food-stuffs are most perfectly oxidized, and urea instead of uric acid is produced, is as near a safeguard as anything in the way of a prophylactic. In renal colic, baths as hot as the patient can bear, or hot applications over the abdomen and loins, relax the tissues and lessen the pain, but they do not arrest the muscular contraction on the part of the ureters as much as does the administration of ether or chloroform. In conjunction with the heat, the internal administration of full doses of belladonna and strychnine will diminish the irregular and spasmodic contraction of the muscular coat of the ureter, while the normal and even peristaltic action will be intensified, and its expulsatory power increased.

Opium and anæsthetics are to be avoided, if possible. The anæsthetics tend to diminish the peristaltic action of non-striated muscle-fibres, and hence prevent the movements of the calculus along the ureter. They will, of course, if given in sufficient quantities, relieve the pain, but when the patient recovers from their influence he is no better, and the stone has made little or no progress in its descent. They are, however, of service in relaxing the tissues and giving the patient a rest.

Opium is usually inefficient, for the same reason as the anæsthetics, and besides it has a dangerous element. To completely alleviate the suffering in these cases, enormous doses of the drug may be required. If now, for any reason, the calculus should slip through into the bladder, the necessity for the opium at once disappears, and the patient may become suddenly narcotized, which might prove both a troublesome and a serious, if not a fatal, complication. For this reason great care should be exercised in reference to the quantity of opium administered, either by the mouth or hypodermatically.

In cases in which a calculus is retained in the pelvis of the kidney, and complications make their appearance, nephrotomy is probably the only treatment that will afford relief. But in those cases in which the stone becomes lodged in the ureter, the method described by Mr. Reginald Harrison, in a paper entitled "On the Possibility and Utility of Washing out the Pelvis of the Kidney and Ureters through the Bladder," may be of service. Mr. Harrison narrates the following case in his paper: A middle-aged man was under observation for acute renal pain, which was assumed to be due to a renal calculus. Nephrotomy was suggested, but the patient would not submit. The stone finally was believed to be lodged in the ureter. The previous passage of renal calculi led to the supposition that the ureter was dilated. Acting upon this theory, and after washing out the bladder, the organ was filled with tepid water, upon which pressure was exercised by the evacuator usually employed in litholapaxy. The patient at once became conscious of something moving in the back, and subsequently half a teaspoonful of phosphates and uratic debris was removed. This process was repeated on several occasions with a similar result, and gave much relief. Clinical facts such as these, taken in connection with pathological specimens, show that it is possible to reach the kidney in this way, and that the escape of calculi may thereby be facilitated.

This method of treatment, however, can only be of service when the ureters have previously been dilated. In the primary attack of a calculus, or in other diseased conditions of the ureters, it would not be wise, even if it were possible, to distend the bladder with the view of secondarily dilating the ureter.

URETERITIS.—A simple uncomplicated ureteritis probably never occurs. Inflammation of the ureter is usually, if not always, due to the passage of a calculus, the extension of an inflammatory process from the renal pelvis downward, or from the lower portion of the urinary tract upward and backward. Whatever the local symptoms are, they are so masked by those of the exciting cause that they in themselves become unrecognizable. If there is pain and irritation along the course of the genito-crural nerve, with retraction of the scrotum in the male, or of the labia majora in the female, it is reasonable to suppose that the ureter is involved in the diseased process.

RUPTURE OF THE URETER followed by recovery has been reported in a few cases. As there are no necropsy records in connection with ruptured ureters, it is impossible to say with accuracy what the pathological phenomena are in such instances. The probability is that rupture acts like an occlusion or ligature of the ureter, and causes an arrest of the functional activity of the kidney, followed by an atrophy of the gland and a complete collapse and obliteration of the ureter.

New Growths in the Ureters.—Various neoplasms have been found to invade the ureters, but in almost every instance the new growth in the ureters has been secondary to a primary disease in the kidney or bladder. All the symptoms present will be more directly traceable to the primary condition, and this renders it almost, if not absolutely, impossible to locate any diseased condition in the ureter alone.

The two new growths most frequently found invading the ureters are carcinomatous and tubercular neoplasms, secondary to a similar condition existing in the bladder.

The writer has found but one instance of a new growth in the ureter at the post-mortem table, during an extensive experience of more than ten years. In this case there was a general tubercular infiltration of the membranous and prostatic portion of the urethra, of the prostate, of the wall of the bladder, and of both ureters up to the pelves of the kidneys. This extensive development of new tissue had not occluded the lumen of the genito-urinary tract, nor in any way impeded the discharge of urine; and, so far as known, had not given rise to any marked symptoms during life.

The patient from whom the specimen was obtained was a laboring man, who was accidentally killed while at work, and the necropsy revealed this extensive diseased condition of the genito-urinary tract.

Congenital Malformations in the shape of two or more ureters arising from a common pelvis are very frequently found. As a rule they join to form a common ureter before entering the bladder, but in a few rare instances they have been found to pass separately through the vesical wall. The presence of valve-like folds, causing partial or complete occlusion of the ureter, is not infrequently recorded among the malformations of the ureters. *William Henry Porter.*

[1] Transactions of the Ninth International Congress, 1887.

[2] Lancet, March 10, 1888.

UTERUS: EPITHELIOMA OF THE CERVIX. Pathological Anatomy.—No more fitting introduction to a description of the various forms of carcinoma of the cervix uteri could be found than the following words of Lusk: "The old familiar division of uterine cancer into scirrhus, medullary cancer, colloid cancer, and epithelioma, has at the present time ceased to be tenable. It was based upon tactile impressions, physical appearances, and peculiarities of growth. It represented not distinct varieties, but accidental conditions, or successive stages of development. It served to introduce into the subject an element of confusion detrimental to progress, as rarely two observers were found in agreement as to the classification of the disease in the same patient. A true pathology is necessarily based upon minute structure, modes of development, and variations due to site."

The general acceptation of the views of Ruge and Veit has materially altered not only the hitherto entertained opinions as to the origin and early development of cancerous disease of the neck of the womb, but the whole nomenclature of the subject, so that it is no longer expedient or correct to speak, for example, of epithelioma, of scirrhous, or medullary carcinoma of this locality, but it becomes necessary to class all of these forms under the generic term cancer, and to establish new subdivisions in accordance with "minute structure, modes of development, and variations in site."

For the purpose of elucidating the subject under discussion Ruge and Veit divide the neck of the uterus into two parts, the portio vaginalis, extending from the external os uteri to a point a little above the vaginal fornix, and the cervix proper, that is to say, all that part of the collum lying above the vaginal portion. In the first of these locations—the vaginal portion,—while the malignant disease may appear under various forms, the nodular and cauliflower varieties are the most distinctly marked and the most commonly observed. Cancerous nodules may appear near the superficies, which, breaking down, leave ulcers behind of varying depths; or a pre-existing benign papillary erosion gradually changes its character, presenting at first a sharply bounded, finely granular, slightly depressed, and faintly yellowish area, and, subsequently, as the malignant process advances, a pronounced fungous or cauliflower-like excrescence, which may ultimately attain such dimensions as to fill the entire vagina.

In all forms of cancer of the vaginal portion the tendency of growth is downward, and if other tissues become involved by direct extension of the disease, or by metastasis, they are such as lie below the level of the external os, a point that is respected in the early development of carcinoma of the portio vaginalis.

The erosion glands—neoplastic glandular formations found in the erosions or catarrhal patches on the surface of the portio vaginalis—constitute unquestionably the fons et origo of a large majority of the carcinomatous affections in this location. The minute changes which result in a transformation of an erosion, which is generally considered a very insignificant pathological entity, but which Ruge and Veit regard as a not always simple and unsuspicious process, need not be discussed at length in these pages, which are concerned more particularly with the clinical aspect of cancer of the cervix. Suffice it to say that the various stages of change and development have been fully recognized and described, and the etiological significance of childbirth, and the resulting lesions and pathological states of the neck of the uterus, at once, therefore, become obvious.

One other variety of cancer of the portio vaginalis remains to be mentioned, namely: that which, beginning in a proliferation of the connective tissue beneath the epithelial investment of this part of the neck, finally breaks through and gives rise to a cauliflower-like growth similar to that previously described.

In the cervix, as distinguished from the portio vaginalis—a distinction which is of considerable importance both from a pathological and clinical stand-point—carcinoma may also develop, either from the connective tissue underneath the mucous membrane of the cervical canal, or from glandular structures. In the first of these two forms a cancerous nodule appears in the substance of the cervix beneath the sound mucous membrane. The disease may subsequently extend upward into the lower segment of the corpus, downward into the portio vaginalis, outward into the parametrium, but finally breaks through the mucosa of the cervical canal, leaving an ulcerating crater often of considerable depth. The malignant process does not, however, tend to involve the mucous lining of the cervical canal, nor does it readily pass beyond the limits of either the internal or the external os.

In the second variety, akin to the malignant adenoma of the corpus, the cervical glands proliferate enormously, invading the substance of the cervix, obliterating its tissue framework, and extending thence in various directions.

Or again, in a third type, the cylindrical epithelium clothing the cervical mucosa proliferates considerably, forming an epidermoidal stratum similar to cancer of the skin, epithelial processes from which subsequently invade and destroy the underlying stroma.

Hofmeier shows with what frequency the different portions of the neck of the uterus are primarily affected by carcinoma: In 812 cases of cancer of this organ the portio vaginalis was first attacked in 236, and the cervix in 181, while in 367 no mention pertinent to this point is made.

In the early advancement of these different forms of cancer, the various modes of progression already pointed out are pursued, but when the disease, whatever its origin, reaches a certain point, all boundaries are swept away, and it devastates the environing tissues on all sides. Not only, on the one hand, does ulceration destroy all anatomical barriers opposed to it, but the numerous lymphatic vessels of the pelvis gather up and hurry off the germs of infection to deposit them far and wide, where they in turn become fresh foci of disease. Thus the vagina becomes involved through direct contiguity of tissue, and the vesico-vaginal, and more rarely the recto-vaginal, septum crumbles away and fistulæ are formed. The ureters may be compressed by cancerous infiltration in the bladder-wall near their points of exit, or by the infiltrated connective tissue which they traverse, or, finally, by deposits in their own structure; from any or all of which simple or double hydronephrosis results, leading in the latter instance to grave uræmic manifestations that may be suddenly mitigated by the breaking down of the affected areas. In a large number of instances the kidneys suffer other grave structural alterations, and exhibit various forms of degeneration in their secreting apparatus, and not infrequently contain purulent collections.

The rectum, aside from the loss of a portion of its wall, becomes inflamed, as do also the uninfected portions of the bladder and vagina.

Should gangrene extend upward, the corpus uteri gradually melts away until it forms simply a suppurating shell, or indeed becomes absolutely destroyed.

The pelvic connective tissue, at first inflamed and subsequently infiltrated with carcinomatous disease, becomes dense, resistant, and inelastic, so that the functions of the bladder and rectum may be markedly crippled long before these structures are themselves directly attacked.

It is not surprising, what with the well-known close anatomical relations of the pelvic contents and the abundant means of intercommunication, that the peritoneum ere long should participate in the ever-advancing morbid process. That portion of the peritoneum in nearest proximity to the disease becomes inflamed and adhesions are formed, which to a certain extent are conservative and protect the general peritoneal cavity. Nevertheless, the products of decomposition may be carried upward into, or burst through, these barriers, and the patient will rapidly succumb to an acute, general, purulent peritonitis. Diffuse cancer of the peritoneum is rarely encountered.

The pelvic glands are frequently enlarged and transformed into cancerous masses that subsequently soften and break down, and the ovaries, with which the former are often confused, become implicated in a certain proportion of cases.

The formation of thrombi and emboli is facilitated by the condition of the blood and by the feebleness of the circulation, and is directly induced by the compression or invasion of an artery or vein—usually the latter—by a portion of the carcinomatous growth. This, with the coagulum formed about it, is swept away as an embolus.

Metastatic deposits of cancer likewise may occur in any of the near or remote viscera.

It is, of course, not to be supposed that these morbid processes are to be observed singly. In any neglected case of carcinoma of the neck of the uterus many, and, indeed, most, of them are exhibited at some time during its course, and the pathological picture usually presented is one of great diversity.

At this point it may be permitted to introduce some numerical evidence of the frequency with which the various organs and tissues of the body become involved in the cancerous degeneration beginning in the cervix uteri.

According to Gusserow, who details the results of Blau's investigations as well as his own, in 311 cases of carcinoma there was infiltration of the bladder in 128 and vesico-vaginal fistula in 56. In 93 cases there was pyelonephritis in 10, parenchymatous nephritis in 4, atrophy of the kidney in 7, amyloid degeneration in 4, cloudy swelling of the uriniferous tubules in 2, and metastatic deposits in the kidney in 5. In 282 instances of this same affection the rectum was invaded 53 times and recto-vaginal fistula developed in 27. Wagner found the rectum involved in 32 of 171 cases.

It would be inexpedient to finally dismiss the topic of the morbid anatomy of carcinoma of the neck of the uterus without making some allusion to the work recently performed in Germany by Abel, Fränkel, Thiem, Saurenhaus, Orthmann, Eckart, and others, in determining the condition of the corporeal endometrium in cases of this character where the malignant degeneration is confined to the cervix or portio vaginalis. These investigations, if they have accomplished nothing else, have proved very conclusively the origin of a large part of the bleeding which occurs before the period of ulceration, and, even without the confirmation of Abel's views, have exercised considerable influence upon the selection of operation.

K. Abel, in examining seven uteri removed by Landau for carcinomatous degeneration limited to the cervix or portio vaginalis, found that the mucous membrane lining the body was the seat of very pronounced pathological changes, which in five of the seven, owing to the presence and peculiar arrangement of round or spindle cells and the absence of any signs of inflammatory reaction, could only be interpreted, he asserts, as sarcomatous degeneration of the endometrium, which, in three of the cases, was quite far advanced. In the remaining two cases there was marked inflammation of the mucosa, which involved both the glands and the interglandular substance, but nothing pointing to the existence of a new growth could be discovered.

Investigations were at once instituted in various directions to ascertain the correctness of these opinions; for if sarcoma of the corporeal endometrium occurs as frequently along with cancer of the neck as Abel would indicate, then the survival of so many women after supravaginal amputation of the cervix in the past would be a matter of surprise, and for the future total extirpation would become the only justifiable, because the only radical, operation in this affection.

Fränkel examined 6 specimens, 4 removed by total extirpation during life, and 2 from patients dead of inoperable carcinoma; Thiem, 9 specimens from living subjects; Saurenhaus, 50; Orthmann, 10; and Eckart, 10, making in all 85 uteri, the condition of whose lining membrane was studied. The result was practically identical in every instance. The utricular glands and interglandular structures, now one, now the other, oftenest both, were found to exhibit those changes which are commonly regarded as characteristic of chronic endometritis. The microscopical sections showed practically the same pictures as Abel had observed, but the interpretations of these findings were unanimously opposed to his.

It may be safely maintained, then, not only upon the authority of those already mentioned, but upon that of others, notably Ruge, who have expressed very decided opinions in this matter, that in cancerous degeneration limited to the cervix uteri or portio vaginalis the mucous membrane of the body of the uterus exhibits in nearly every instance very pronounced pathological alterations—alterations which are quite typical of "glandular hypertrophic" or hyperplastic endometritis, and again of endometritis interstitialis, with a tendency to the development of vessels in the mucous membrane," and, therefore, of various well-known morbid processes which are constantly seen, and may be called forth by a variety of causative agents; but the coincident occurrence of sarcoma of the endometrium is as yet very far from being proven.

ETIOLOGY.—In the discussion of epithelioma of the cervix, age is a factor of etiological significance which at once claims our attention. In spite of the alleged inconsistency and unreliability of statistical evidence, in the present instance it will be admitted, I believe, that such evidence is everywhere in accord. It is true that the disease has been observed in children of tender years, in adolescents, in early womanhood, and, again, in the very aged; but nevertheless, it is universally acknowledged that women at or about the time of the climacteric are most subject to the ravages of this loathsome affection. Thus Gusserow's analysis of 3,385 cases of cancer of the uterus shows that at seventeen years there was 1 case; at nineteen, 1 case; between twenty and thirty there were 114 cases; between thirty and forty, 770 cases; between forty and fifty, 1,169 cases; between fifty and sixty, 856 cases; between sixty and seventy, 340 cases; and over seventy, 134 cases.

The results of Hofmeier's investigations are in agreement with the foregoing, for he found that the average age in carcinoma of the portio vaginalis was forty-two years, and in carcinoma of the cervix forty-seven years.

Ganghofner, however, has recently reported an instance of carcinoma of the portio vaginalis occurring in a girl aged eight; Eckart, one of carcinoma of the cervix in a girl aged nineteen; and Schauta, from Späth's clinic, has described a tumor of the vaginal portion in a girl of seventeen, which showed the transition form between adenoma and carcinoma.

Several factors, doubtless, contribute to the increased prevalence of uterine cancer at the time of the change of life. With advancing years there is a greater tendency to retrograde tissue-metamorphosis throughout the whole human organism, and, locally, the effect of the vascular alterations incident to a general readjustment of the blood-current is of unquestionable etiological importance.

With regard to heredity as a predisposing cause of cancer of the cervix, or, indeed, of any other portion of the body, it is safe to say that we know next to nothing. Whatever information bearing upon this point is to be obtained from hospital patients is eminently untrustworthy, and it may be justly questioned whether, with the prevailing ignorance of disease among even the more intelligent of the laity, the evidence obtained from them is of any scientific value.

Occasionally, it is true, we are startled by such an incident as, for example, is recorded by Broca, where everyone of four daughters and ten grandchildren of a woman who died of cancer of the breast were themselves the subjects of carcinomatous affections. Barker also mentions a family of which eight members succumbed to this disease, and, more recently, Guttman records three cases of cancer of the uterus among seven sisters; but in the first instance it is distinctly stated that there was no history of malignant disease among the immediate ancestors, and in the second the matter is not referred to. Indeed, all the evidence that has been accumulated, if it proves anything, goes to show that the importance of heredity in this connection has been much exaggerated.

From Gusserow's statistics, founded upon 1,203 cases of cancer of the uterus seen in the private practice of himself and others, it would appear that in only 7.8 per cent. could any account of the previous existence of this disease be obtained, and no recent authority records a higher proportion than this. Such a small percentage can hardly be regarded as more than a coincidence.

It has been maintained that cancer of the uterus is less often met with among the whites of this country than among those of the same race living in Europe, and, further, that in America the negroes are not so frequently affected with this disease as the whites. Emmet states that he has known but a single negro woman, and she a mulatto, who had cancer of the uterus; and, according to Chisolm's statistics, carcinoma is more than twice as frequent among the white population than among the black. I have found in my own clinic at the Central Dispensary in Washington, D. C., that cancer of the cervix occurs on an average in 1.2 per cent. of all negroes, and in 0.6 per cent. of all whites examined; and in estimating these proportions I have included only those cases where the diagnosis of cancer admitted of not the least atom of doubt.

Excluding constitution, temperament, occupation, and the social state as etiological factors of doubtful import, we are next confronted with a series of associated conditions deserving of the utmost consideration. It has been proven beyond question that cancer of the uterus is far more common in fertile than in sterile women; and, furthermore, that those who are the subjects of this affection have borne a larger number of children than is usual during married life.

Thus among 1,540 cases collected by Gusserow, including some of his own, only 121 were sterile; in 812 mentioned by Hofmeir but 39 were without offspring; and in 55 cases in Reamy's practice there was 1 single and without children, and 1 married and sterile. While, according to the first of these authorities, in Prussia every married woman has, on an average, 4.6, in England 4.2, and in France 3.4 children, the proportion in 3,025 cases collected by himself was 5.1 children for each mother. Hofmeir reports that among 849 fertile women with cancer of the uterus, observed in the Berlin Polyclinic and Schroeder's private practice, 106 had had one child, 667 had borne on an average 5.8 children, and 76 had been pregnant more than ten times. Winckel's figures are quite as convincing, for in 130 cases of uterine carcinoma ten per cent. were I.-paræ, 40.8 per cent. were II.–V.-paræ, and 49.2 per cent. were VI.–XXVI.-paræ. In the 55 cases heretofore referred to as mentioned by Reamy, 53 had had 217 pregnancies.

Now, with these facts in mind, it is very easy to proceed a step further to the point from which parturient injuries of the cervix and their pathological sequences are to be regarded as causative agents of malignant disease of the most pronounced importance. Emmet's views upon this matter are well known, and in them he is supported by Mundé, Goodell, Breisky, and others; but it is quite certain that while these latter may believe that "the occurrence of this form of malignant disease in a woman who has never been impregnated must be exceedingly rare," yet few are prepared to state, with Emmet, that they have "never known a woman to have any form of epithelial cancer of the uterus unless she has at some time been impregnated." Cervical catarrh, ectropium, erosions, and neoplastic glandular formations are processes or conditions which lead to, and, indeed, are often undistinguishable from actual carcinomatous disease; and while such a pathological picture may be presented by the vaginal portion of a virgin, it is in parous women that we are accustomed to see them, with or without appreciable laceration of tissue, most often and in their most pronounced forms. Nevertheless, there are certain links in this chain of argument which are wanting to make it perfect. While it is of service to know that cancer of the cervix is most frequently encountered in those who have been many times pregnant —and it is better to adopt this phrase, for many of the pregnancies in the foregoing enumeration of cases terminated abnormally early—yet it is more with the character of the ensuing labors than with their number that we are interested; and though, personally, we may be convinced of the causative importance of injuries of the cervix uteri and their pathological accompaniments and results in the development of epithelial cancer, yet we do not have at this time adequate ground for making broad generalizations. Convincing evidence can alone be furnished by a series of extended observations like those of Wells in Mundé's practice, by which it was shown that more than a third of a given number of cases of carcinoma of the cervix were known to have previously suffered cervical tears. Spanton and others have seen epithelioma springing up in a cervical rent.

The belief of Emmet that cancer of the cervix is encountered more often in the well-to-do than in the poorer classes of society is in accordance with his own, and the generally entertained opinion, that lacerations of the cervix occur no less often in the former than in the latter. That such lesions may be observed with greater frequency among the poor is doubtless true, and the reasons for this I have elsewhere attempted to point out.

SYMPTOMATOLOGY, PROGRESS, AND RESULTS.—Of all the diseases which may afflict womankind, nowhere is early recognition more important than in carcinomatous affections of the cervix uteri. In many of her ills the morbid state throws out sundry hints, warnings of approaching danger, that serve to put her on her guard and lead her to seek relief while yet it may be obtained. Here it is otherwise; nature is less beneficent, and the appearance of symptoms too often leads but to the discovery of an advanced stage of this horrible affection, and predicates the abandonment of hope. The signs of the stages through which it has already passed are indefinite, if not altogether negative. Of such as exist we know little. In spite of what has been taught us in recent years and what we ourselves see, we still cling tenaciously to that tradition which makes cancer of the uterus, whatever be its kind or degree of progress, indissolubly associated with hæmorrhage, with foul discharge, and with agonizing pain. But, as H. Meyer puts it, he who first suspects cancer when such symptoms are present will never find it in its early stages.

Of all the affections which a physician may be called upon to recognize and treat, cancer of the cervix is one with whose earliest manifestations he should have the most intimate acquaintance. Discovered in time it is amenable to cure; neglected, death is inevitable.

Considering this one disease, how great becomes the responsibility of the general practitioner, of whom, naturally, advice is first sought, and how great is the need of new light upon the symptomatology of its incipient stages. As has been already said, if there be any disturbances which occur during the early life-history of cancerous disease of the cervix uteri we are unacquainted with their nature, and in the existing state of our knowledge we are obliged to fall back upon those symptoms which become manifest, with rare exceptions, only when ulcerative disorganization of the infiltrated tissues has begun.

Bleeding probably first attracts the attention of an observant woman, but it fails in the vast majority of instances to excite more than a passing curiosity as to its origin. If her suspicions are aroused they are quickly set at rest by the explanations and asseverations of her female friends. This bleeding, it should be at once understood, is not hæmorrhage. It is small in quantity, usually not exceeding a drop or two, occurs quite independently of menstruation, and usually ensues upon traumatism, therefore following coitus or, as in a case of my own, the introduction of the tip of a syringe into the vagina. Unusually pronounced physiological excursions of the uterus, such as are induced by certain forced or sudden movements of the body, straining at stool, etc., may also, through traumatism, bring about the same result. This "show" could only occur were the disease seated upon the portio vaginalis, and is far from distinctive of malignancy, as is well known. In the benign papillary erosion or catarrhal patch, and in the primary stages of the epithelioma developed therefrom, before ulceration has taken place, local injuries will be followed by rupture of some of the thin-walled and dilated vessels so superficial as to be exposed to every injury, and bleeding will result.

Again, it is with menorrhagia or metrorrhagia that the disease first manifests itself; but this is due, as Coe and Eckart have pointed out, to the accompanying endometritis already fully described in these pages.

Irregular but not profuse hæmorrhages occurring before, at the time of, or after the establishment of the menopause, are usually regarded as quite typical of this time of life, and when they take place in a woman with cancer of the uterus both she and her medical attendant may be lulled into a feeling of fancied security, from which sooner or later there is to be a rude awakening. If ever during life, at or about the climacteric period the slightest disturbance must be viewed with the utmost suspicion and subjected to the most critical investigation. These "atypical" hæmorrhages, whatever be their frequency or quantity, are pathological and must be so regarded.

With the advance of the cancerous process, the discharge of blood becomes a more pronounced symptom.

Heretofore that which has occurred has been largely the result of general uterine hyperæmia. Now the infiltrated tissues press upon the veins, diminish the amount of the return current, while blood-pressure is decidedly increased, and vessel-rupture takes place. The vascular and luxuriant cauliflower excrescences projecting into the vagina, should the disease take that form, likewise give rise to considerable loss of blood; and when by ulceration the wall of some vessel of relatively large size is opened, the hæmorrhage may be profuse and exhausting. Usually, however, when the carcinomatous affection is in its incipiency, and occasionally when ulceration has far advanced, there may be nothing but a thin, pinkish discharge from the genitals. Indeed, although bleeding may be said to be the earliest and most constant symptom of cancer of the cervix, it is uncommon to observe pronounced hæmorrhage, and death from such cause is extremely rare.

Discharges of various kinds other than blood are likewise almost invariable accompaniments of all of the different forms of the disease under discussion. At first there is no discharge, or a slight, thin, inodorous, serous flow may appear, which, like the bleeding occurring at the same time, may simply result from the hyperæmic condition of the corporeal endometrium, may be an accompaniment of an antecedent erosion, or may follow from the incipient pathological changes at the site of the future new growth. This discharge may be quite clear, or pink, or streaked with blood, or reddish from blood-admixture. After ulceration has begun it becomes distinctly purulent, and in the more advanced stages of the affection, when the neoplasm has become gangrenous, it assumes a dirty yellowish or reddish-brown color, becomes mixed with shreds of disorganized tissue, and exhales an odor so foul and penetrating that it makes the sufferer a horror to herself and poisons the atmosphere around her.

There is no pain distinctive of commencing malignant disease of the cervix. As Coe has suggested: "It should be remembered that the patient has already an extensive laceration of the cervix of long standing, and probably the remains of former perimetritic inflammation, the symptoms of which would mask any fresh ones produced by the incipient cancer." He himself has observed sciatica in several instances of beginning epithelioma. Whatever vague pains in the back or pelvis occur at this time can usually be ascribed to peritoneal irritation. Later, when the cancerous infiltration has invaded the parametrium, tearing, dragging, or lancinating pain is complained of, which owes its origin to pressure or traction exerted upon the nerve-filaments or trunks ramifying in this locality. Should the disease extend upward so as to invade the body of the uterus, pain from the same cause may be a pronounced symptom, as also when the vaginal walls become involved.

It may be said, indeed, that there is no suffering experienced by the patient as long as the disease is confined to the cervix uteri, but that with infiltration of surrounding tissues pain begins, to subside often with the advance of ulceration.

The cancerous cachexia is to be observed only when the disease has made considerable advancement. Until this time the patient may appear to be robust and well. Ultimately the appetite fails, there are gastric catarrh, perhaps vomiting, and constipation. In consequence digestion, assimilation, and nutrition become seriously impaired. Anæmia and the absorption of the products of decomposition still further deteriorate the general health, until, finally, the unfortunate woman, to use the words of Lusk, becomes wan, yellow, and wrinkled, and wears an aspect of profound suffering.

Toward the end many complications arise which still further increase the distress of the patient and hasten the final issue. Thus uræmia, œdema of the lower extremities, cystitis, proctitis, vesico- or recto-vaginal fistulæ, and intolerable pruritus, are frequent concomitants of the further extension of the disease. In spite of the amount of sloughing tissue and the imperfect escape of the products of decomposition, septicæmia and pyæmia are not common, for the infiltrated and inflamed areas beyond the region of gangrene go far to diminish the absorption which is favored in every other way.

It is next to impossible to determine with any accuracy the duration of life in a case of epithelioma of the cervix. From what has been already said it is evident that the clinical history of the disease in its incipiency is practically unknown to us, and our only method of determining its duration is to count from the date of the appearance of the first pronounced symptoms, a time usually synchronous not with the beginning but with an advanced stage of the disease. It is commonly estimated that from this period until death, in instances where no treatment, or only such as is palliative is instituted, not more than one year and a half elapses, although a fatal termination often occurs sooner, and occasionally life is more prolonged.

That death is the inevitable result in neglected cases is a well-established fact, and the reported instances of so-called spontaneous cure are neither sufficiently numerous nor sufficiently conclusive to warrant a different belief.

In a disease like cancer of the cervix, which is attended by so many and such wide-spread complications, it is not surprising that the possible causes of death are numerous. In 155 cases of this affection, according to Gusserow, death occurred 38 times from some form of peritonitis. Among the 93 fatal cases recorded by Blau, the final issue was due in 48 to marasmus, in 11 to pneumonia, in 3 to pleurisy, in 3 to embolism of the pulmonary artery, in 1 to pyelo-phlebitis, fatty degeneration of the heart, pulmonary gangrene, and pyelo-nephritis, respectively. In the 62 cases from Seyfert's clinic, mentioned by Säxinger, there were 9 deaths from pyæmia, 5 from amyloid degeneration of the abdominal glands, 3 from œdema of the lungs, 3 from dysentery, and 28 from uræmia.

It is next to impossible in any given case to ascribe the death of the patient to any one cause. The unfortunate is set upon on all sides by a host of enemies against which it is impossible to cope. Digestion, assimilation, nutrition, secretion and excretion, respiration and circulation —all the functions whose proper performance is necessary to health—in multifarious combinations become interfered with and gradually overwhelmed, until finally death comes as a welcome release to the tortured and exhausted sufferer.

DIAGNOSIS.—The importance of the early recognition of cancer of the neck of the uterus and the general ineffectiveness of the means in our possession to attain this end have already been referred to. The subjective symptomatology of all stages of this disease has likewise been noticed. Those forms of cancer which begin either upon the outer aspect of the portio vaginalis, or in the connective tissue immediately beneath the mucous membrane covering it, are most likely to be discovered by physical examination while yet in their incipiency.

It should be remembered that the neck of the uterus probably already exhibits a more or less pronounced laceration, with ectropium, erosion, ovula Nabothii, and general hyperplasia of its tissue, and the assured determination of minute cancerous nodules beneath the mucous membrane or of a beginning malignant change in an erosion is a matter requiring the greatest possible degree of tactile skill and familiarity with the diseased conditions in this locality. The presence of small, hard nodules over which, possibly, the mucous membrane is immobile, in parts of the vaginal portion where there is no cicatricial plug, may point to the existence of one form of beginning cancer. It goes without saying that, since the microscope often fails to distinguish between a benign papillary erosion and one in which malignancy has already developed, the differentiation of these conditions by unaided sight or by touch is a matter of the most extreme difficulty. Such areas probably bleed more readily when the seat of beginning carcinoma, but this is purely a relative sign and without much value.

Stratz points out that the diseased portion is sharply separated from that which is healthy ; there is a difference in level between the diseased and healthy areas ; the former is at a lower level and has a hard surrounding border, and the malignant surface has always a faint yellowish color and is covered with finely granular whitish-yellow elevations, at least in some places. The same author, however, observes that clinical observation alone, far from determining the diagnosis of commencing carcinoma, can only raise suspicions which the microscope is called upon to settle. But from the fact that the material sent to the microscopist is often inadequate, and because of the close similarity in minute structure between the benign papillary erosion and the malignant papilloma, even the microscope often fails, as in the cases cited by Landau, to settle the matter finally. If the portion of doubtful tissue submitted to the microscopist is sufficiently large to permit of many sections being prepared from it, is removed from the most suspicious portion of the cervix, and is made to include not only the mucous membrane but a considerable portion of the underlying muscular tissue, his opinion will be immeasurably enhanced in value.

It behooves the examiner, being assured that there is malignant disease present, to ascertain with the greatest possible accuracy its extent ; for only in this way can an operation be selected which is at all likely to be followed by radical results.

The diagnosis of cancer in its advanced stages is easy and requires no comment.

THE MUTUAL RELATIONS BETWEEN CANCER OF THE CERVIX AND CHILDBEARING.—I must confess that I can see no reason for the statement, so often repeated, that pregnancy occurs very readily in the early stages of cancer of the cervix. The fact that patients with this disease have usually reached the limit of childbearing life, and from repeated pregnancies have already pretty well exhausted their procreative powers, militates decidedly against any such assumption. Furthermore, it is in just such women that one would expect to find the results of parturient injuries of the cervix. These are universally regarded as causes of sterility ; and since some forms of beginning epithelioma are simply pathological exaggerations of the changes which follow lacerations, and others, to all intents and purposes, are undistinguishable therefrom, it seems irrational to assume *a priori* that incipient cancer favors conception. Nor, aside from pre-existing lacerations, ectropium, and erosions, is there anything in the commencing malignant changes in a previously uninjured cervix that would seem to make pregnancy anything but difficult. In fact, in spite of Cohnstein's statement that in 127 pregnant women with cancer of the cervix there were 21 in whom the disease had been recognized for a considerable time before the occurrence of pregnancy, it is admitted on all sides that the complication of childbearing with this affection of the cervix is extremely rare. Thus, according to Stratz, in 1,034 cancer patients observed in the last ten years in the Woman's Clinic of the Royal University in Berlin, conception occurred in but 1.16 per cent., and in 17,832 deliveries which took place during the same time only 0.039 per cent. were complicated by this disease.

Conception may occur even in women with far advanced carcinoma of the uterine neck, but such a circumstance is extremely uncommon.

It is generally agreed that during utero-gestation the malignant affection, as would naturally be supposed, makes extremely rapid strides ; and yet many have observed instances in which there seemed to be no progress, or in which the disease advanced with great slowness.

Provided pregnancy occur in a woman with cancer of the neck of the uterus, there is developed one of the most frightful complications which the physician can be called upon to meet. In such cases, according to Lewes, forty per cent., to Cohnstein, fourteen per cent., and to Stratz, from thirty to forty per cent. abort or suffer premature delivery. Occasionally, however, pregnancy goes to full term, and, rarely, is still further prolonged, owing, as Pfannkuch suggests, to the fact that the density of the lower uterine segment is sufficiently great to overcome the efficacy of uterine contractions, and because the destruction of important nerve-endings at the seat of the disease may prevent the reflex stimulation necessary to bring on labor.

When delivery occurs it becomes prolonged, difficult, or dangerous in proportion to the amount of resistance offered by the infiltrated cervix and lower portion of the corpus uteri. Expulsion of the child may be, indeed, impossible, or is accomplished only at the cost of wide-spread laceration and crushing of tissue.

The mortality to both mothers and children, in the event of the coexistence of utero-gestation and advanced cancer of the neck of the uterus, is enormous. Chantreuil reports that of 60 cases 25 mothers died during, or immediately after, labor, and 29 children were born dead. Herman mentions that in 180 confinements 72 mothers died, and of 114 children of whom record was made but 58 were born alive. According to Cohnstein's investigations spontaneous labor terminated favorably for the mother in 37.5 per cent., and for the child in 33.3

per cent. of the cases; but when the disease was advanced only 34.7 per cent. of the mothers recovered and but twenty-five per cent. of the children were born alive.

The treatment of a pregnant woman suffering from cancer of the neck of the uterus requires much consideration. When it is remembered that the vast majority of such individuals die either directly from the effects of labor, or, should they survive, are probably beyond the reach of material help, the life of the child becomes a matter of the greatest importance. Surgical interference during pregnancy is very apt to be incomplete, and there is added the risk of abortion or premature delivery. At term the accoucheur may expedite labor by securing enlargement of the cervical canal by dilatation or incision, and by rapid manual or instrumental extraction of the child, or through craniotomy if the child be dead.

When the disease during utero-gestation is so far advanced as to threaten the life of both mother and child, it may be well to have resort to some palliative operation in order, if possible, to keep the patient alive until the child is viable and then induce premature labor. In instances where the disease apparently is not extensive, in the interest of the mother it might be well to sacrifice the child, inducing abortion, and then performing total extirpation of the uterus.

Cæsarean section may be undertaken near the normal end of pregnancy in cases where delivery, per vias naturales, appears to be impossible, or hedged about with difficulties and dangers. This is certainly the most assured way of preserving the life of the child, and should be attended with less risk for the mother than when labor is allowed to take place in the usual manner.

According to Herman, up to 1879 the maternal mortality of Cæsarean section under these conditions was 72.7 per cent., and in 12 cases collected by him, 10 children were removed living from the uterus.

Among 135 Cæsarean sections done according to Sänger's method, between May 25, 1882, and October 1, 1888, and recorded by Sänger (Nos. 1-10), Credé (11-50), and Caruso (51-135 inclusive), in four instances the operation was performed upon women suffering from cancer originating in the cervix uteri. All the children and two mothers were saved. The operators were Jewett, of Brooklyn; Ehlers, of Braunschweig; Lusk, of New York; and Merkel, of Nürnberg. Frank, of Cologne, and Goodell, of Philadelphia, have very recently performed Cæsarean section for the same indication. In the case of the former, a twin pregnancy, one child was already dead and partly macerated, but the other child and the mother were rescued. In Goodell's case both mother and infant were doing well on the thirteenth day, the date of the report. Frank's operation was performed according to a method of his own, and was reported by Beaucamp.

TREATMENT.—Such general treatment as is necessitated during the various stages of carcinomatous disease of the cervix uteri need be here described in no detail. Until the effects of infiltration are felt in pain, and of destruction in hæmorrhage and exhausting discharge, the physician's counsel is usually not sought. The management of the patient during the later periods and closing scenes of the affection taxes all the resources at our command. Gradually one system is involved after another, and life finally becomes simply an exhibition of variously diversified combinations of morbid phenomena.

Really, all general treatment expresses only the effort made to prolong existence, or to make it more bearable, and at last with narcotics to cheat death of its horrors.

The effect to be exercised in the future upon the whole matter under discussion in these pages, by the establishment and careful and intelligent conduct of hospitals especially designed for the treatment of cancer, cannot be at present estimated. Not only will they become a refuge where these miserable sufferers who have abandoned hope may find some mitigation of their wretchedness, but also sources of instruction in everything which pertains to this dreadful disease for their corps of medical attendants, both old and young, and through them for the whole profession. The mortality of ovariotomy has been immensely lessened by the early recognition of ovarian tumors and the improved technique employed in their removal. Ectopic pregnancy is no longer a condition of whose early history we know nothing and for which we can do nothing. And cancer of the cervix, which in its incipiency is as much a localized affection as any other, may, largely through the influence of the institutions of which I here speak, cease to be a synonym of all that is most horrible in a woman's life.

It is impossible, in discussing the treatment of carcinomatous disease of the cervix uteri, to institute any formal divisions or subdivisions, or to speak with any degree of accuracy of symptomatic, palliative, or radical therapeusis. The treatment of the vast majority of symptoms is practically the treatment of the disease. A so-called palliative procedure may be unexpectedly followed by the complete extinguishment of the affection, and the most radical of all operations—total extirpation—not only proves in a large number of cases to be an utter failure as far as complete cure is concerned, but, on the other hand, has been performed where the disease was known to have passed beyond limits that technically could not be overstepped by the surgeon; where, therefore, the operation becomes a palliative and not a radical procedure at all.

Almost any operative method or device which is directed against the disease in situ may be either palliative or radical. Even the simplest may be completely effective when the disease is limited to the anatomically isolated cervix; but when it has insinuated itself through or swept aside anatomical boundaries the most thorough may prove a dismal failure.

Unfortunately, we have no means of knowing what ground cancer has already occupied by its outposts. Areas of thickening and resistance along possible avenues of travel may indicate where the disease is already present in force; but who can follow the smaller bodies of the enemy as they scatter far and wide, invading only to devastate?

With regard to prophylaxis, it need only be said that since cancer of the neck of the uterus is most common in women who have had many children; since a very large proportion of these have either suffered a visible laceration of the cervix, or else some less pronounced parturient injury; because we know what are the almost inevitable pathological accompaniments and sequelæ of such injuries; and because it is certain that the transition between the most common of these accompaniments and sequelæ and cancer has been clearly demonstrated, and is so slight a change as to leave the most careful examiner often in doubt as to whether the existent condition is benign or malignant; admitting these statements to be facts, the only logical deduction to be drawn from them is that a laceration or other injury of the cervix uteri must be regarded as an important pathological entity, and quite independently of any subjective symptoms that may or may not be present at the time, and, therefore, must be repaired early and repaired thoroughly. Any other disease involving the various tissue-elements making up the neck of the uterus should no less receive attention.

In the succeeding lines some of the methods of treatment employed with the object of mitigating or thoroughly eradicating the disease in question will be discussed, and the arrangement followed will imperfectly indicate the various steps in the history of the treatment of cancer of the cervix.

The removal or destruction of cauliflower excrescences projecting into the vagina, of cancerous ulcers, or of sloughing masses, and the infiltrated tissue in their immediate neighborhood, by spoons, curettes, caustics, etc., at one time regarded as an effective method of treatment, is now employed practically only in so-called inoperable cases, and the object aimed at is not cure, but relief and prolongation of life through prevention of hæmorrhage, gangrene, and foul discharge.

With a curette, sharp spoon, or scoop, assisted by knife or scissors, as much of the disorganized tissue is removed as possible, and while it is desirable to do this thoroughly and to go deeply, care must be exercised not to wound either the bladder, rectum, or peritoneum.

After this removal has been satisfactorily accomplished, selection may be made from a large variety of methods of subsequent treatment. The wound may be at once cauterized with heated irons or with the Paquelin instrument, and this also should be done in no superficial or perfunctory manner. The excavation produced can be kept clean by iodoform powder and an iodoform-gauze vaginal tampon ; or a pledget of some absorbent material saturated with alcohol may be introduced instead. A large number of cauterizing agents have been employed, alone or in diverse combinations with other procedures ; among them, bromine, nitric acid, carbolic acid, Vienna paste, caustic potash, the positive pole of the galvanic current, and chloride of zinc ; the last, perhaps, the most extensively. Sims, as is well known, in 1879 extolled the virtues of chloride of zinc ; Van de Warker, in 1884, again brought it to the attention of the profession ; and more recently still (1888) Fränkel, of Breslau, has proven its utility when preceded by the use of the spoon and the Paquelin cautery. In 50 cases of so-called inoperable carcinoma of the cervix in Fränkel's hands, there were 6 in which the disease was thus radically cured. After the spoon and actual cautery have been employed, iodoform is sprinkled over the wound, and an iodoform-tannin-gauze tampon is placed in the vagina. When the separation of the charred tissue occurs, provided no suspicious points are visible, Fränkel advises that a small pledget of some absorbent material, soaked in a 2-to-3 solution of chloride of zinc, be placed in the excavation, while the vagina is protected by an ointment or tampon containing bicarbonate of soda. The cotton soaked in zinc is removed in from twelve to twenty-four hours, and a thick, grayish-white scab is apparent, which becomes detached in from eight to ten days, leaving a surface covered with healthy granulations. With the aid of disinfecting vaginal injections and loosely placed iodoform-gauze tampons, the wound rapidly cicatrizes.

As Fränkel suggests, these various steps should be modified from time to time to suit the exigencies of individual cases ; the strength of the chloride of zinc solution should not be invariable, but should depend upon the depth of cauterization which it is desired to achieve, and the length of time that the tissues are to be exposed to its action. He believes, finally, that recurrence *in loco* is more uncommon or longer postponed after the use of chloride of zinc than when other drugs of a like character have been employed.

Still, as Ehlers and others have pointed out, the idea that chloride of zinc exerts any specific action upon cancer is untenable, and while its use is admirably adapted to certain cases of advanced carcinomatous disease, yet it is not always possible to limit its action to the affected area, and sound tissues may be attacked even when it is carefully employed.

I should like at this point to refer to a rather unique method advocated by J. Schramm, of Dresden, in the treatment of inoperable carcinoma of the cervix. This author especially recommends the injection of antiseptic fluids directly into the cancerous tissues. He believes that, even if the existence of a micro-organism as the causative factor in cancerous disease has not as yet been firmly established, yet sufficient has been proved to make a procedure like the foregoing a rational one. He employs a solution of corrosive sublimate. A needle of a hypodermic syringe is carefully introduced into the carcinomatous mass until slight resistance is encountered, and the fluid is then gently evacuated drop by drop. This injection is repeated, sometimes deeply, sometimes superficially, two or three times a week. No fear of sublimate intoxication need be entertained (although 0.008 to 0.010 gramme of the antiseptic is employed at each sitting), for the absorptive power of the degenerated tissue is almost nil. The malignant mass, it is claimed, is kept clean by this treatment, the purulent discharge ceases, further destructive change is diminished, hæmorrhages become less frequent, and the general condition of the patient improves.

Repeated and prolonged vaginal irrigation with very hot water, specially commended by Tornery, or the use of disinfectant and deodorant solutions, particularly those containing permanganate of potassium, or a two per cent. solution of creolin (as suggested by Coe), are of great service in combating the ichorous discharge and the foul odor which surrounds the patient like a noisome exhalation. Iodoform powder and loose iodoform-gauze tampons, likewise, employed in the intervals between the injections, are of the greatest utility.

Terebene, Chian turpentine, and Alveloz, have their place in the treatment of the advanced stages of cervical carcinoma. Each has its special advocate, but it is probable that we could get along very well without them.

With the view of thoroughly eradicating the carcinomatous disease when it is confined to the cervix uteri, numerous operative procedures have been proposed and practised. The object sought in all of them is, not only the removal of such tissue as shows palpable signs of degeneration, but also of that beyond which is, or is likely to be, infiltrated ; the operation being continued, therefore, well into areas which, so far as can be ascertained, are free from the slightest suspicion of malignant invasion.

When the portio vaginalis alone, the cervix alone, or both together are the seat of cancer, and there is reason to suppose that there has been no further extension, the amputation, or better, excision, of a part or the whole of the neck of the womb should offer fair chances of immediate and permanent success. Even the most thorough operation of this kind presents few difficulties and is attended with a low rate of mortality ; and further, the ultimate results are quite satisfactory, as will be shown immediately.

The portio vaginalis may be amputated by the écraseur, galvano-cautery, or knife and scissors. Even the most improved écraseurs are difficult to use, are liable to do injury, and possess no special advantages. The cautery wire is not always easy to apply, but diminishes the chances of hæmorrhage during and after the operation. The fact that it cauterizes the tissues left behind is at once an advantage and a disadvantage. For, while this charring of the stump may in one sense be regarded as advantageous, it nevertheless may prevent the appreciation of the fact that the operation has not been thorough, and that distinctly infiltrated spots remain in the wound.

The ablation of the vaginal portion with scissors is to be preferred to either of the methods of procedure just described. To those who are accustomed to the performance of plastic operations upon the cervix, it offers no difficulties whatsoever. To be thorough, the cervix should be split into an anterior and posterior half, and each lip exsected beyond the limits of the portio vaginalis proper, so that a triangular wound is left whose base is formed by the vaginal roof, and whose apex reaches to or beyond the internal os uteri. Thus, while some of the tissue of the cervix remains, the mucous lining and submucous strata of the canal are removed,—a point of considerable importance when it is remembered that these areas are early affected by the gradual upward extension of the disease when it originates below, and may themselves be the seat of a coincident malignant process. It is better, it would seem, to pursue this plan of operation than to have recourse to any of the more formal methods whereby a portion of the mucous membrane of the cervical canal is preserved. Deep silver sutures, or the actual cautery, if it is not desired to approximate the edges of the wound, will control any hæmorrhage that may ensue, and a hollow glass stem pessary or roll of iodoform gauze will prevent the complete closure of the cervical canal. We should here be dominated by the thought that we are operating for a disease whose limits of extension are not ascertainable by any means in our possession, and should, for the sake of thoroughness, forego the satisfaction that one necessarily feels in doing a neat plastic operation.

As has been already mentioned, the immediate and remote results of the various operative methods of ablation or excision of the vaginal portion, with or without cerable parts of the cervix—in brief, of all removals of the neck of the uterus short of supra-vaginal amputation—have been very satisfactory. Gusserow has assured himself that radical cure was obtained by Simpson, Marschik, Zeemann, C. Mayer, Martin, Grünewaldt, Schultz, Hegar, and Sebastian. C. Braun has operated 166 cases, with the following results: 10 deaths, and 16 patients received no benefit. Of 140 immediate recoveries, 52 subsequently died, but only 16 of actual recurrence; 22 patients were lost sight of; 33 remained well for from one to eleven and a half years. Schroeder reported 13 cases, of which number 1 died of trismus. Of the remaining 12, 4 suffered a recurrence within two years, and 8 continued well at that date. Byrne, of Brooklyn, has used the galvano-caustic wire in 300 cases, and has never seen recurrence at all.

Schroeder's supra-vaginal amputation of the cervix, the next operation to be described, is indicated when the carcinomatous disease has begun in the cervix, or in the more advanced forms of certain varieties of cancer of the vaginal portion; but in either case, for the operation to be permanently effective, there must be no extension beyond the neck of the uterus.

It should be said at once, however, that no specific indications for any of the preceding or succeeding operative procedures can be formulated; that no inflexible rules for the guidance of the gynecologist can be laid down. Each operator must judge of each case upon its own merits; and while statistics may give a fair idea of the immediate and remote results which pertain to any individual method, it is a question whether anything can be learned from their comparative study. With the passage of time, the constant tendency has been toward the adoption of more and more radical measures, even in cases where those which were less bold and thorough were formerly thought to be satisfactory enough. This tendency may be accounted for by the increased confidence which gynecologists have begun to feel in their operative skill, and also by the fact that the frequency of recurrence after less pronounced surgical interference has excited everyone who has the welfare of his profession at heart, to seek out some new method which theoretically should be followed by greater immunity from return, and whose utility can be practically tested. We are not in a position to-day to decide between the merits of many of these operations. It is a very easy thing for a writer to describe what has been done, but it is another matter when it comes to be said what should be done. Ovariotomy may be a closed book, but cancer of the cervix is practically one which is just being opened, and he who will come nearest to the solution of the riddles contained therein must have, aside from any personal qualifications, a large material at his command, and the possibility to follow up his cases.

In the supra-vaginal amputation the cervix is first brought down and separated from its vaginal attachments by knife or scissors. The connective tissue in which the cervix proper is embedded is next stripped off with the finger, the bladder likewise is freed, and ascends, carrying the ureters with it beyond the risk of injury. When the summit of the cervix is reached, first one half and then the other is cut away, and the anterior and posterior portions of the stump are stitched to the vaginal mucous membrane, respectively at the front and back of the incision made through it. It is a matter of choice whether the incision through the vaginal fornix is first made in front, behind, or at the sides of the cervix; and of indifference whether the pouch of Douglas is opened or not, provided, of course—it is almost unnecessary to say—that the operation is conducted with the utmost regard to surgical cleanliness.

One or two features of the operation, however, require special comment. Hæmorrhage may originate from the divided surface of the vaginal wall, and it is sometimes necessary, when this has been attacked by cancerous ulceration, to resect considerable portions of it, in which case small clamp-forceps or a suture passed parallel to the incised surface and around the bleeding vessel will usually be sufficient. But troublesome bleeding is far more liable to result from the vessels which enter at the sides of the cervix, where also the connective tissue is most dense. This may be controlled by forci-pressure, or by one or more ligatures previously introduced on a curved needle carried high through each lateral vaginal fornix, as in the first steps of vaginal hysterectomy. It is best, also, after separating, let us say, of the anterior wall of the cervix, to sew the stump to the corresponding portion of the wound in the vagina, for hæmorrhage thereby is controlled, and by traction upon the long ends of the ligatured suture the cervix is prevented, when the posterior wall is divided, from escaping beyond our reach.

There are numerous other technicalities and modifications of Schroeder's supra-vaginal amputation of the cervix about which it is unnecessary to describe. Hofmeier has recently given in complete detail the method pursued in Schroeder's clinic during the closing years of the latter's life.

Statistical evidence bearing upon the safety and ultimate effectiveness of this operation, as well as of Baker's, Freund's, and of vaginal hysterectomy, will be cited at the close of this article.

In our advance from the simplest to the most radical methods employed in the treatment of carcinoma of the neck of the uterus, allusion must next be made to that described by Baker, of Boston, in 1882 and again in 1886. In this operation the cervix is freed from its attachments and removed as in the supra-vaginal amputation. Then with a uterotome a funnel-shaped excavation is produced, whose base is on a line with the internal os, and whose apex approaches or meets the fundus of the uterus. "It is thus possible to remove the entire cervix, both infra- and supra-vaginal, and at the same time nearly or quite one-half of the body of the uterus, and that the most important half; for cancer of the body of the uterus, whether of primary origin or of extension from the cervix, affects the glandular structure first, and by the method I have described, this, its natural habitat, is removed or destroyed" (Baker). The edges of the vaginal wound, provided not too much has been removed, as may have been made necessary by the extension of the disease in that direction, should next be stitched to what remains of the lower part of the uterine wall, and the actual cautery is then applied to the whole denuded surface. In this operation the diseased portions of the vaginal walls, and, with some slight modifications, the para-cervical connective tissue, along with the whole of the neck and a considerable portion of the body of the uterus are removed. Practically nothing remains but a rounded shell of healthy muscular tissue with a thoroughly charred cone-shaped interior. Baker's results have been most gratifying, as will be seen later on.

In 1878 Freund, of Strasburg, introduced an operation that has subsequently borne his name, which consists essentially in the removing of the entire uterus by abdominal section, the broad ligament of each side being tied off in three portions before being divided, and the separation of the vagino-uterine attachments being accomplished by dissection made from within outward.

Even in the hands of the most skilful and experienced German operators—for in Germany its practicability was most often tested—Freund's operation has been attended with such disastrous results that, even though it afforded an absolute guarantee against the recurrence of cancer, which is very far from being the case, it could in its original form be no longer classed in the category of legitimate operations.

Long before this time, namely, in 1822, Sauter, of Constance, had performed total extirpation of the uterus per vaginam, and the operation was repeated by Blundell, in 1828, and Recamier in 1829. After being forgotten or neglected for many years, it was revived by Czerny, of Heidelberg, in 1878, and was soon thereafter taken up by Billroth, Schroeder, and others in Germany, and by operators generally throughout the world. It will be impossible to bestow more than a glance upon this operation of vaginal hysterectomy, or total extirpation, upon the indications for its performance, its imitations, technique, difficulties, and dangers; for since its introduction, ten years ago, such an amount of attention has been given it that the mere enumeration of the literature that has accumulated during this period would be a limitless, if not an impossible, task.

Vaginal hysterectomy is a surgical procedure which is at once radical and comparatively safe. At the present time there is no means in our possession of so thoroughly eradicating cancerous disease of the uterus. It is applicable in all the cases in which supra-vaginal amputation is performed, and can be resorted to when this latter operation would be merely a palliative and temporary expedient. The tendency of the time is toward the adoption of vaginal hysterectomy, to the exclusion of all other operative means of combating cancer of the cervix. That, of course, each has its indications and limitations goes without saying. But since no one can know before removal of the uterus how extensively its lining membrane is affected by secondary, incipient, malignant degeneration; nor whether isolated and coincident carcinomatous disease exists therein; and because recurrence *in loco* has so frequently been observed after less radical methods of removal where everything gave the most assured promises for the future; even the most experienced and conservative gynecologists of late have entertained and expressed a preference for total extirpation as against less thorough modes of operative interference. As Brennecke has pointed out, if the uterus is removed the patient will be spared the risks of a subsequent pregnancy, and Landau maintains that the uterus to a woman past the childbearing age is of no use whatever. Furthermore, Brennecke observes that extirpation of the uterus puts an end to the free monthly bleeding due to coexisting endometritis; but it might be urged that Baker's operation, thoroughly done, would be quite as effective.

A great deal might be said upon the opposite side of this question, and there are doubtless not only many instances where the removal of the uterine neck would have been quite adequate to annihilate the malignant disease, but also where the uterus has been extirpated for supposed cancerous, but really perfectly benign, conditions. Reeves Jackson is a bitter opponent of total extirpation. He maintains that "Kolpo-hysterectomy is more dangerous and has given worse results than any other method of treatment. It has destroyed and not saved life. It is an injurious and not a successful operation. It is more rapidly destructive of life than the disease against which it has been used. Hence it should be condemned as unjustifiable."

Whether vaginal hysterectomy is an operation which warrants all the trust imposed in it by some, or deserves all the opprobrium cast upon it by others, time alone can show.

The absolute restriction of the cancerous affection to the uterus is the most favorable condition for the immediate and remote success of vaginal hysterectomy. It was, and still is, generally believed, that unless there is sufficient evidence to warrant the assumption of such limitation, total extirpation is contra-indicated. It certainly, in this sense, cannot be regarded as a radical operation. But we are unable to affirm that the disease is confined to the uterus, although the extreme mobility of that organ and the freedom from induration in its surroundings, doubtless point in that direction. Still, on the one hand, the extension of cancer is not always appreciable by the senses of which we make use in examining women, and on the other, quite distinct areas of thickening may be due to the remains of a previous para- or peri-metritis antedating and unconnected with the malignant disease of the cervix.

Vaginal hysterectomy is, however, no longer confined within the narrow boundaries which formerly hedged it in. In certain quarters these boundaries are being extended, and in cases where no hope of radical cure can longer be entertained, total extirpation is recommended as the best of all palliative methods of treatment. Many of those whose names are identified with the history and progress of the operation under discussion—among them, Richelot, B. Schultze, and Brennecke—would extend the limits of the operation to the utmost bounds of technical possibility. It is argued that no other palliative procedure secures to the patient such marked and prolonged relief. Thiem is an ardent advocate of this aspect of the question, and points out that if recurrence takes place after vaginal extirpation, it is not as an ulceration, but as a tumor formation in the scar. The woman, therefore, may die of cancer of other organs or of cachexia, but is spared the horrible gangrenous degeneration in the vagina which of all things makes carcinoma of the cervix such a loathsome affection. With due regard to the universal applicability of Fritsch's axiom—"aussichtslose Operationen zu machen ist ein inhumaner Sport,"—Thiem believes that total extirpation in every case offers the best chances to the patient, and that all so-called inoperable cases are really operable so long as the operation is within the bounds of technical possibility.

It would be impossible to describe all the modifications of technique that have been introduced in vaginal hysterectomy. Most of them, as Martin shows, are really matters of no great importance, as is proven by the almost uniform results obtained by different operators using different methods. There are a few which have exercised a considerable influence upon the history of the operation, and to these reference will be made.

The patient is prepared in much the same way as for any important surgical procedure; the condition of the gastro-intestinal canal, skin, and kidneys receiving special attention. A few days before or immediately preceding the operation, the degenerating cancerous mass which presents in the vagina should be removed, and, indeed, it may be expedient to excise the entire cervix. The hair should be shaved from the external genitals, which are then cleansed thoroughly with soap and water, and afterward with some antiseptic solution. Every effort should be made to render the vagina completely aseptic, and to this end repeated irrigation with a 1 to 1,000 or 1 to 2,000 sublimate solution should be practised; or, bearing in mind the experiments of Döderlein and Günther in the disinfection of the parturient canal, the mucous membrane must be thoroughly scoured, if I may use the term, with a sublimate or creolin lotion. The operator, his assistants, and attendants, should be no less careful about themselves and the instruments, etc., employed.

The time for the operation having arrived, the patient, lying on her back, is brought well to the edge of the table, and with the aid of anterior, posterior, or lateral retractors, and sometimes all are necessary, the vaginal portion and vaginal roof are exposed. The portio vaginalis is seized with a vulsellum forceps and drawn downward; or, if this has been previously removed or the forceps does not hold, a stout ligature may be passed through what remains of the cervix, or the uterotractor of Bernays, or endoceps of Richelot or of Brennecke may be introduced directly into the uterine cavity. The cervix is then to be freed from its anterior and posterior vaginal attachments and from its surrounding cellular atmosphere, and the connections of the posterior bladder wall are to be liberated in the manner described when speaking of supra-vaginal amputation. It is a matter of indifference whether we begin the operation in front or behind the cervix; but the plan of attacking the lateral vaginal fornices first (Polk, Fritsch) commends itself from the fact that not only is subsequent hæmorrhage thereby diminished, but the uterus at once attains an increased degree of mobility, and can be easily moved in different directions by the forceps or ligature attached to it. Constant irrigation of the field of operation can be practised up to this point, and now it is well for the operator to cleanse his hands and to employ fresh instruments and sponges, provided the latter have been used before.

Either the anterior or posterior peritoneal pouch may be first opened, the peritoneum being seized with a forceps, a button-hole made in it with scissors or knife, and the membrane then cut or torn in each lateral direction.

The most important part of the whole operation of vaginal hysterectomy is the securing of the broad ligaments in such manner as best to prevent hæmorrhage from the divided edges when the uterus is cut away. Practically, all the important vessels encountered by the operator run beneath the peritoneal duplicature constituting the framework of these ligaments. Formerly the ligament of each side was tied en masse, the fundus often being turned over and brought through the opening in the anterior or posterior cul-de-sac to facilitate this manœuvre. Various modifications and combinations of different methods of procedure have been introduced from time to time, the object of all being to give the utmost security against hæmorrhage. The demonstration by Richelot of the applicability of certain forms of long, stable forceps was an important step in advance. It has been shown not only that forceps can be trusted quite as much as the ligature, but that they can be adjusted more easily, more rapidly, and further, can be employed in certain cases where the use of a ligature would be impossible. The utility of the forceps has been advocated by Richelot, of Paris; Landau, of Berlin; Müller, of Berne; Hunter and Polk, of New York; and Dudley, of Chicago.

When the ligature is used, as is almost universally the case in Germany, a curved needle armed with stout silk is introduced through the lower portion of the broad ligament of one side, the ligature is tied, and the ends left long. The tissues lying between the ligature and uterus are then divided. This process is repeated, constantly going upward, until, finally, the summit of the broad ligament, with the Fallopian tube, ovarian artery, and pampiniform plexus is included in the last ligature and, after this is tied, the attachments of the uterus on that side are entirely severed. The other side is treated in the same way, a very much easier matter, and finally the uterus is completely freed and delivered. Certain operators tilt the fundus uteri through an opening previously made in the anterior or posterior cul-de-sac to render easy of access the summits of the ligamenta lata, but others satisfy themselves with traction on the uterus in situ.

When the forceps is used, it is best, as Richelot suggests, first to make an opening anteriorly and posteriorly in the peritoneum. The index-finger of the left hand introduced through the latter acts as a guide along which one blade of a long forceps, such as those devised by Doléris or Polk, is inserted. The other blade is passed through the anterior opening, and the finger hooked over the top of the broad ligament draws it down within the grasp of the blades, which are then clamped, and the tissues lying between the forceps and the uterus are divided. Again, especially when this manœuvre is difficult or impossible, forceps with shorter blades are used, and the broad ligament is seized and divided in tiers, as described by Hunter (of New York), the pincement par étages of Richelot. The number of pairs of forceps requisite to control all hæmorrhage is sometimes enormous. They are removed usually in from twenty-four to seventy-two hours.

Hæmorrhage may originate from sources other than those already described, but can usually be controlled by small compression forceps, or, if from the divided vaginal wall, by transfixing and tying around the vessel.

Occasionally during the course of the operation the bladder is wounded, or along with a necessary resection of a part of the vaginal wall it may become advisable to remove a part of the bladder. In either case the fistula should be at once closed.

Great care must be exercised to avoid injuring the ureters with cutting instruments when operating in front of the cervix, and to prevent including them in the ligature or grasp of the forceps. Such unfortunate accidents have occasionally occurred (Richelot, Kocher, Lannelongue, Doumer). After having divided the anterior vaginal wall the finger alone should be employed to free the supra-vaginal cervix, and when this separation is carried to a sufficient degree in a lateral direction, there will be slight risk of catching the ureters when employing either of the hæmostatic measures just alluded to.

After the uterus is removed there remains a large funnel-shaped cavity. A considerable diversity of opinion exists, or rather existed, as to the treatment of this wound, for now it is generally considered quite judicious to leave it alone. With the idea of preventing intestinal prolapse and infection from without, but at the same time of securing adequate drainage, a host of procedures have at various times been inaugurated. Bouilly recounts no less than thirteen. At the present time, however, a large number of operators discard all suturing and artificial methods of drainage, contenting themselves with placing in the vagina a loosely made tampon of iodoform or creolin gauze. The wound under favorable circumstances heals rapidly and firmly. The patient, as a rule, behaves after vaginal hysterectomy more like a puerpera than a woman who has undergone a serious operation. The ligatures or forceps are removed as already indicated, and the dressings changed at or near the end of a week. Then, after gently practised vaginal irrigation, some fresh iodoform gauze is loosely inserted into the vagina. The urine is drawn by catheter for two or three days, and a movement from the bowels is secured on the fifth to the seventh day. In the second or third week the patient may be allowed to sit up.

Lusk observes that "the safety of the woman after extirpation of the uterus depends upon strict antisepsis and the careful control of hæmorrhage at the time of operation," and it is unquestionably true that death after vaginal hysterectomy is usually due to lack of these precautions. Nevertheless, ileus may develop after the operation, in a manner described in detail by Reichel, and at least five deaths have been due directly to this cause, or have followed laparotomy undertaken for its relief. These fatal cases have been reported by Bokelman (death from intestinal obstruction on the seventh day after total extirpation of the uterus), Leopold (death on the fourth day), Landau (abdominal section for intestinal occlusion, the case terminating fatally on the day next succeeding), and Reichel (death during laparotomy on the seventh day, and a second case, where the patient succumbed twenty hours after abdominal section on the ninth day after operation). A. P. Dudley has recorded a case in which the bowel became obstructed one and a half years after the vaginal operation, but an entero-vaginal fistula formed and the patient recovered.

Sometimes during the operation of total extirpation of the uterus the ovaries and tubes prolapse and may easily be removed. It is best, it may be said, to remove them in every woman who has not reached the climacteric, and wherever else it can be done without unduly prolonging the operation; for it adds nothing to the danger, and undoubtedly materially enhances the future comfort of the patient. The ovaries without the uterus can serve no good purpose whatever. Even Brennecke, who maintains that their removal is attended by no special advantage, admits that in all of his patients where this was not done there was marked pain of different kinds for one or more days, at regular intervals, for the first two to six months after the operation, accompanied by epistaxis, flushing, headache, and other disturbances of a distinctly molimenal character. His opinion is that the ovaries soon cease performing their usual functions and atrophy, but Grammatikati, who to ascertain what really became of the ovaries after total extirpation of the uterus performed experiments upon numerous rabbits, comes to a different conclusion. The latter insists that the ovaries continue to functionate, and that no change can be discovered in the ripening or rupture of the Graafian follicles or in the structure of the false corpora lutea. The specimens removed from a patient, dead of an intercurrent disease three years after vaginal hysterectomy, strongly supported this view.

Here are certainly a sufficient number of operative procedures to be employed in the various stages of cancer of the uterine neck to suit the most exacting, and Schroeder's modification of Freund's operation, Rydygier's combination of Freund's operation and vaginal hysterectomy, and numberless other methods of surgical interference, should still be mentioned. But it is in very few instances of the disease that anything beyond mere palliation can be secured. The proportion of cases that have passed beyond all hope of permanent relief is simply enormous. The number of those which are unsuitable for even the most radical of the palliative methods is great. Leopold, in 250 cases, found that but 42 could be designated operable, and the experience of Thiem, Schatz, Cordes, of Geneva, and in fact of every gynecologist, is almost precisely the same.

The choice of operation in a given case, as is self-evident, depends upon many considerations. A number of these determining factors are apparent at a glance, while others depend upon the individuality of the operator. As Lusk observes, complete cure can only be secured by removal of every particle of diseased tissue; but whether this can best be done in one way or another is a matter which cannot as yet be considered fully determined.

It may be well, therefore, while admitting that statistics are not always conclusive, to append an outline of the results obtained through the employment of some of the operations just described, in the hands of a few well-known and conscientious gynecologists.

1. *Supra-vaginal Amputation of the Cervix.*—Schroeder's statistics, as recorded by Gusserow, 1886: Number of cases, 105; deaths from operation, 13; recoveries, 92; lost sight of, 27. Twenty-seven showed recurrence within six months; 38 remaining well at this time. Twenty-seven well after one year; 22 after eighteen months; 18 after two years; 15 after two and a half years; 12 after three years; 5 after four years. The remaining cases were lost sight of, or experienced a recurrence.

Martin, 1887, says that the operation mortality, according to Hofmeir, is 7.4 per cent., and that fifty-five per cent. of surviving patients remained well at the end of the first, and thirty-three per cent. at the end of the fourth year. His own immediate mortality was twenty-one per cent., and every survivor was the subject of recurrence.

2. *Baker's Operation.*—Reeves Jackson, 1887, reports 21 operations, with an immediate mortality of 9.5 per cent. Of those who survived, 9 remained well, one after three years and eleven months, another three years and seven months, another two years and two months, another one year and eleven months, another one year and nine months, another nine months, another six months, another five months, and another after four months. In 6 cases there was recurrence and subsequent death. Four patients passed from under observation.

Baker, 1886, records 10 cases with no deaths due to the operation. In 3 there was recurrence *in loco*, and another died of cancer of internal organs. Six of the patients continued well for from four to eight years after the operation.

3. *Freund's Operation.*—Gusserow, 1886, records 148 operations with 106 deaths, a mortality of 71.6 per cent. The disease recurred in every reported case, and ultimately death ensued. Fritsch, 1887, mentions that one patient, operated upon by Freund eight years before, yet lives and is in good health.

4. *Vaginal Hysterectomy* or *Total Extirpation.*—Gusserow, 1886, records 253 operations with 59 deaths following, a mortality of 23.3 per cent.

Pfannenstiel, 1885, quoted by Gusserow to show that the immediate mortality from this operation is diminishing, says that in 154 operations done before 1882 the mortality was twenty-three per cent., while in 36 operations performed since, it was reduced to 8.3 per cent.

Leopold, 1887, records the following immediate results obtained by different operators: Schroeder-Hofmeir, 16.2 per cent.; Martin, 16.4 per cent.; Olshausen, 24.1 per cent.; Fritsch, eleven per cent.; Leopold, 6.2 per cent. Martin in his last 59 cases had a mortality of 8.9 per cent.; Hofmeir in last 50 cases a mortality of six per cent.; Brennecke in last 22 cases lost none.

Mialaret reports, in 1888, upon 77 operations performed by French operators, with an immediate mortality of thirty-one per cent. In those who survived recurrence took place in twenty-five per cent. within one year.

Martin, 1887, gives a summary of 311 operations performed by Fritsch, Leopold, Olshausen, Schroeder-Hofmeir, Staude, and himself, with an immediate mortality of 15.1 per cent. Of Leopold's cases, there were 24 in which some estimate could be made as to permanency of results. Among this number, 16 were free from recurrence at the end of one year, 9 after one year and six months, 5 after two years, and 2 after three years. In 33 of Hofmeir's, 20 were well after one year, 10 after one year and six months, 7 after two years, 4 after three years, and none after four years. In 20 cases of Fritsch's, 17 were well after one year, 7 after two years, and 2 after three years. In 44 of Martin's, there were 35 well after one year, 32 after one year and six months, 25 after two years, 20 after three years, 5 after four years, 3 after five years, and 2 after six years.

Secheyron, 1888, compares the results obtained by French and foreign operators (the latter including German, Russian, English, and American) as follows:

	French, 105 cases.	Foreign, 394 cases.
	Per cent.	Per cent.
Immediate mortality of operation	23.80	15.47
Death from recurrence in	18.80	..
Establishment of recurrence in	23.75	1.80
Recurrence after six months in	8.75	66.43
" " twelve months in	15.00	33.91
" " eighteen months in	7.50	20.97
" " twenty-four months in	5.00	18.18
" beyond this in	3.75	10.48

Terrier, 1888, gives his personal results. Eighteen operations, with an immediate mortality of twenty-two per cent. Four of remaining 14 cases incomplete. In 11 cases left there was recurrence in 7, at sixteen months, six months, four months, four months, three and a half months, three months, and one month, respectively. No recurrence in 4 at two years and nine months, one year and nine months, one year, and nine and a half months after operation, respectively.

Richelot, 1888, reports 13 operations, of which 2 were incomplete. In the remaining 11 there was recurrence in 5, and others are not beyond the danger period.

Fritsch, 1887, records 62 total extirpations performed by himself, with seven deaths. Of the remainder, 10 continued well at one year to one year and ten months; 1 at one year and eleven months; 2 at two years; 1 at two years and three months; 1 at two years and four months; 1 at two years and seven months; 1 at three years and one month, and 1 at three years and two months.

Post, in a series of 722 collected cases of vaginal hysterectomy, found a mortality of twenty-four per cent.

Dudley, 1887, reports that in 66 operations performed by American operators, 23 resulted fatally, while 43 patients survived and remained well for periods varying from three months to three years.

In conclusion, let me insert the statistics given by Hofmeir, and quoted by Lusk and others, illustrating the comparative advantages of supra-vaginal amputation and vaginal total extirpation.

Supra-vaginal amputation, 136 operations with 10 deasth (mortality, 7.4 per cent.), and 47 recurrences within one year. Total extirpations, 74 operations with 12 deaths (mortality, 16.2 per cent.), and 13 recurrences within one year. The ultimate results can thus be shown;

	Patients operated upon by supra vaginal amputation.	Patients operated upon by vaginal hysterectomy.
	Per cent.	Per cent.
Remained well at end of first year	51.0	63.6
" " " second year	46.0	24.1
" " " third year	42.0	26.0
" " " fourth year	41.3	Not one alive.

Many of the total extirpations, which appear in the above statistics, were performed for cancer of the body of the uterus. It was found impossible to eliminate from the whole number those which were done for cancer of the body alone.

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George Woodruff Johnston.

UTERUS: INVOLUTION; SUBINVOLUTION; SUPERINVOLUTION. Involution.—Involution is the process of retrograde metamorphosis by which the puerperal uterus returns from its condition of physiological hypertrophy to the normal non-gravid state. There is a broader sense in which the word is occasionally used, including those cases of reduction in the size of the uterus following the evacuation of retained contents, as in physometra, hydrometra, or hæmatometra, or after the removal of submucous fibroids, uterine hydatids, or other tumors accompanied by hypertrophy. The process in each case is identical, but the latter conditions are relatively so rare that it is best to disregard them and use the word in its relations to pregnancy only.

Every writer upon the subject calls attention to the wonderful nature of the change which occurs. Striking as is the alteration effected in the uterus during the nine months of gestation, by which its weight is augmented twenty-one to twenty-four times, even more remarkable, if possible, is the process of involution by reason of its great rapidity. The increase in size of the uterus is due almost wholly to hypertrophy of the individual muscular fibres, together with the development of new fibres from previously existing embryonic cells, this latter process being probably confined to the inner layer of the muscular wall, and occurring wholly during the first six months of pregnancy.

At the completion of labor the uterus becomes reduced to the smallest possible bulk by the combined contraction and retraction of its walls, the blood-supply is suddenly cut off to a very large extent, and as a result, the process of growth and development gives place to one of fatty degeneration. By this means the muscular fibres are gradually transformed into fat, which is in turn removed by absorption, or by being directly cast off in the lochial discharge. Whether the muscular tissue is thus wholly destroyed to be replaced by newly developed fibres, or whether a part of the existing fibres simply undergo atrophy and still remain a component part of the diminished uterus, is an open question, but the weight of testimony is in favor of the former view. As the organ becomes infiltrated with fat it loses its deep red hue, assuming a strongly yellowish cast. At first almost stony in its hardness during the periods of contraction, it rapidly becomes so soft and inelastic as to be readily perforated by a careless examiner.

Not until the fourth week after labor can the process of regeneration be detected, and then there appear, everywhere throughout the fatty mass, new cells which develop into muscle-fibres and form a new uterus out of the wreck of the old one. The blood-vessels, both arteries and veins, participate in the process of fatty degeneration and atrophy. The mucous membrane is almost wholly shed at the time of labor, and hence has little part in the general retrograde change. It has been claimed, indeed, that it is completely stripped off at the time of labor, leaving the muscular tissue as absolutely bare as does the surgeon's knife; but this view is manifestly incorrect, the membrane remaining almost intact at the placental site, and the deeper layers covering the remainder of the surface. From these fragments of a mucous membrane the new one develops, the regeneration, according to Leopold, being practically complete at the end of six weeks.

It would seem that, concerning so universal and carefully observed a phenomenon as involution, there need be no difference of opinion as regards the rate of its progress and the time of its completion, and yet absolute knowledge of the matter does not exist. The modifying conditions are so numerous, and the methods used by which to arrive at conclusions so various, that no two observers appear to agree. Pathologists judge from appearances found after death, clinicians from the relations of the fundus to the symphysis pubis, statisticians from measurements made either with the pelvimeter or with the intra-uterine sound. Sources of error only too readily creep into the observations in each case, and seriously affect the deductions. Post-mortem examination furnishes, of course, positive results, and yet who can say how much the retrograde process has been interfered with, in any given case, by the illness causing death, or by the other attending circumstances during life? The relation of the fundus uteri to the pubes may depend more upon the amount of prolapse, version, or flexion, the fulness of bladder and rectum, the size of the pelvic cavity, and tension of the abdominal walls, than upon the size of the uterus. It has seemed to me that measurement of the vertical diameter of the uterus by means of a pelvimeter must be unreliable, by reason of uncertainty as to the thickness of the abdominal wall, and as to the importance of existing flexion, and of longitudinal compression resulting from the necessary expenditure of force.

Unquestionably, the best results must be looked for from the actual measurement of the depth of the uterine cavity in a large number of normal cases, at intervals, during the puerperal month. Much has been done in this line of investigation, and yet I know of no results which are at all satisfactory or conclusive. Up to eight or ten years ago, it was taught that reduction in the size of the uterus was most rapid during the second week after delivery, but that not until the end of six weeks or two months was the normal size regained, and this statement was regarded as authoritative until the appearance of a series of intra-uterine measurements,[1] begun by A. D. Sinclair and continued by W. L. Richardson, both of Boston. From these figures there has frequently been deduced the conclusion that involution is much more rapid than was formerly believed, and teaching has been modified in accordance with this belief. This conclusion has been partially corroborated by Charpentier, though his averages are materially larger than those of Sinclair; and Skene, in his recent work, accepts it completely.

Now, were the question at issue merely one of scientific interest, having no important practical bearing upon the management of the puerperal state, it would not properly arise for discussion in this paper, but it has a very vital connection with the vexed questions as to how long a patient should keep her bed after delivery, and how much latitude should be permitted her in resuming her customary avocations; and it has also a plain relation to the remaining topics to be considered under this heading. This being the case, it is not out of place here to call in question the accuracy * of the reported measurements, and to assert that the old belief, founded upon post-mortem investigation, is the correct one, the one upon which all rules of conduct should be based. The reason for so confident an assertion is the knowledge that the measurements, as reported in the papers above mentioned, vary more with the skill and boldness of the house physician in passing the sound, than with the condition of the patient or the duration of her puerperal period. A part of those published were made by myself, and, though septicæmia was rife in the hospital at the time, they evidenced a most phenomenal involution, amounting in some cases to superinvolution. These results I knew to be untrustworthy, and yet they corresponded with the work of my predecessors.

I was succeeded in this line of work by Dr. W. J. Otis, who, believing with me that his sound rarely reached the fundus, and fearing to do injury to a soft and friable uterus by the employment of greater force, entered upon the use of a Jennison elastic sound, to which he adapted a sliding marker or guide. With this soft and elastic instrument, used with gentle yet persistent manipulation, the whole aspect of the figures at once changed, and from that time on only once did the measurement fall below three inches. He has very kindly furnished me with the results of his examination in thirty cases, after the adoption of the new instrument, and from his figures I select the following as indicative of the general conclusion. Of the 30 uteri, 6 had a depth of three inches, 5 of three and a half inches, 4 of three and three-quarter inches, and 7 of four inches. The average depth was 3.63 inches, and the average day of measurement was the seventeenth.

I learn from the house physicians of more recent years, that the depth of the uterus always increases after a few weeks' experience in measuring, and that the figures are uniformly much greater during the service of some men than they are recorded by others. Though septic influences have been absent of late, yet the average depth, I am assured, is greater rather than less than it was found by Dr. Otis. The fallacy in this method of investigation lies in the fact that the uterus is so softened as to be easily perforated, or, at least, penetrated by the sound, thus staying the examiner's hand through fear; is often flexed; is not yet lined by normal mucous membrane, but by a soft exudate in which the instrument is readily entangled; and that upon its inner surface is an elevation corresponding to the placental site, an elevation sufficiently great to obstruct the passage of the sound. The custom of examining upon the back tends to increase existing difficulties, so that I believe the fundus is by no means always reached, even by the most skilled observer, and under the most favorable conditions.

The questions as to the influence upon involution of normal lactation, and of the routine use of ergot after delivery, are eminently practical ones, and deserving of notice. It would seem that so physiological and essential a process as suckling ought to have a favorable influence, especially in view of the intimate relation existing between the breasts and the uterus, any excitation of the former stimulating contractions in the latter. Yet this view is opposed by many observers, notably among the French. Tarnier takes conservative middle ground, hold-

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* Since the completion of this article my attention has been called to a very important series of measurements reported by Hansen, in the Zeit. f. Geburt. u. Gyn., 1887, a review of which by Parvin appears in the Annual of the Universal Medical Sciences for 1888. He examined 200 women, making in all 1,048 sound measurements. He announces that "the duration of involution was in general ten weeks; the shortest period observed was four weeks, and this in only one case, while the longest period was three months, which was observed in four women." Parvin concludes by stating that "one of the most important practical lessons to be learned from the investigations of Hansen is, that obstetricians should insist upon a longer rest for the puerperal woman. When we remember that many a woman is up and at work two or three weeks after childbirth, and that even those whose circumstances in life do not require labor, are frequently participating in social pleasures and fatigues at the end of six weeks and two months, we can easily understand why disorders of the genital organs not infrequently result."

It was also found that involution was delayed in those who did not nurse.

ing that "the individual conditions have a much greater influence upon the course of uterine regression than lactation." In the face of such contradictory truths the chances are that Temple is correct, and the influence of nursing is a factor of minor importance. My own belief is that it is favorable rather than otherwise, provided, of course, that the patient has sufficient strength and vigor for the physiological performance of the function. Under other circumstances the drain might easily result in such physical deterioration as to materially interfere with the involution of the uterus.

Unquestionably, it is the custom of the majority of American physicians to administer ergot, as a routine measure, at the close of labor. Subsequently, should the uterus fail to contract firmly or regression prove tardy, the exhibition of the drug is continued with anticipation of benefit. Of late years, however, the wisdom of these procedures has been disputed by those who believe not only that the practice is useless, but that it is actually harmful, it being claimed that involution is retarded thereby. This theory, while given a respectful hearing, has not as yet found favor in practice, the sanction and approval of the profession being still given to the use of ergot as outlined above.

Among other factors in determining the rapidity and completeness of involution are the duration of labor and amount of resultant fatigue; the condition of the patient's health before labor; the occurrence of lacerations of cervix or perineum; the occurrence of septic poisoning, or of local inflammatory conditions from any cause. These matters will receive more especial mention in the consideration of subinvolution. After abortion or miscarriage, unfavorable conditions being absent, involution proceeds as after normal labor, only more slowly.

SUBINVOLUTION.—Subinvolution is simply a state of persistent incomplete involution, the process having by some means been arrested before the uterus has fully regained its normal state. Corresponding with the intensity of the acting cause and the time of its occurrence, the uterus may remain very large, as at the close of the first week, or it may be only moderately hypertrophied. From this fact probably has arisen much of the uncertainty which still exists as to the exact nature of the condition and of the subsequent changes which take place. So great, in fact, is this uncertainty that few writers can agree even upon a name which suitably indicates the nature of the disease; those who make use of the term "subinvolution" acknowledging that it is only clinical in its application and by no means covers the progressive pathological changes; those who classify it under the heading "chronic metritis" for the most part disclaiming any belief in its inflammatory origin or course; and the terms "engorgement" and "infarctus" indicating only phases of, or steps in, the progress of the disease. "Chronic parenchymatous metritis" is open to the same objection as "chronic metritis," because suggesting inflammation. Thomas, in absolutely denying any inflammatory element, suggests and uses the title "areolar hyperplasia," as descriptive of a condition of the uterus of which subinvolution is by far the most frequent cause, thus considering the latter not as a separate disease, but rather as a merely fugitive condition giving rise to "areolar hyperplasia."

However, it matters little what one chooses for a name, if only he recognizes the fact of arrested involution and acts accordingly, as witness the statement of Hart and Barbour:[1] "The term subinvolution is convenient, and simply expresses the mode, the most important, in which the condition to be described (chronic metritis) is produced. Apart from the history, it is not possible to diagnose between a subinvoluted uterus and one enlarged from chronic metritis alone. Further, the condition of subinvolution is maintained by the process of chronic metritis, that is, by the formation of connective tissue which takes the place of the fattily degenerated muscular fibre. Finally, the treatment is the same in both cases." In other words, whatever the conditions in the early stages of the disease—whether involution has been arrested in the first puerperal week by septic absorption, with a resultant uterine or periuterine inflammation, or in the fourth week by a mechanical displacement—there results sooner or later, in consequence of continued hyperæmia and irritation, a proliferation of connective tissue, with ultimate contraction and hardening of the whole uterine mass. These later stages constitute the "chronic metritis" or "areolar hyperplasia" above mentioned.

As regards the method by which the normal enlargement is perpetuated, there are at least two definite and diametrically opposed views, both of which, as has already been intimated, may be consistently held to be correct. Courty says:[2] "The hypertrophy of the uterus by failure of the retrograde evolution is a pathological hypertrophy by its permanence, but resulting from a purely physiological hypertrophy in its origin." He quotes West as claiming a fatty change with lack of absorption of the product, and claims the contrary to be true. He states that there is not a change in the texture of the uterus but a "persistence in the number and volume of its component elements. There is not a fatty change of the uterus," but an hypertrophy by excess of nutrition.

On the other hand, Hart and Barbour state that "the condition of permanent enlargement of subinvolution is not due to the non-degeneration of muscular fibre, but to the substitution of connective tissue for the products of this degeneration."

In view of this difference of opinion, and in the lack of positive testimony on either side, it is fair to infer that subinvolution is produced in both ways, the precise process being determined in any given case by the acting cause. In either case the final result would be the same, the method of its production having been minutely described by Dr. Mary Putnam-Jacobi[3] as a structural alteration in the walls of the enlarged blood-vessels, "in virtue of which nutritive transudations of an albuminous plasma took [*take*] place, which gradually caused [*cause*] a local development of connective tissue (perivascular sclerosis)." This process she claims to be inflammatory in its nature.

Etiology.—In entering upon the subject of the causation of subinvolution, we are at once in a wide and important field for discussion—wide because of the multiplicity and variety of the causes alleged; important because of the necessity for their recognition and consequent avoidance or removal. The first and most fruitful source of subinvolution is without doubt laceration of the cervix. There are some who still dispute this fact, but their number is rapidly growing less, and it is to be hoped that before many years there will be as great unanimity in asserting the necessity for closing lacerations of the cervix uteri, as there is now in urging repair of the perineum after injury.

The testimony of Emmet in this matter may be considered somewhat biassed, yet the accuracy of his observation and the truthfulness of his statement can hardly be called in question. He says:[4] "In closing this brief chapter I would state that, for many years past, I have met with few or no cases of subinvolution which were not due to laceration of the cervix." T. A. Reamy, in the "American System of Gynecology," pointedly remarks "that if a laceration of the cervix is observed, more or less subinvolution, either of the whole uterus or of the cervix alone, is almost absolutely certain."

The means by which the result is produced is not difficult to understand. In the first place the presence of an open wound, and later on, either a mass of cicatricial tissue or an everted and eroded surface of mucous membrane, serves as a constant source of irritation to keep up an active hyperæmia of the uterus. However, in the early weeks the very effort of nature to repair the damage is opposed to the process of involution, and subsequently, as the wound remains and the irritation persists, the permanence of the hypertrophy is insured by the development of an endocervicitis and endometritis. It is not necessary that the laceration should be a large one, for even very superficial tears, if exposed to the deleterious influences of an irritating vaginal discharge and denied by the restlessness or too early effort of the patient the quiet needed for repair, may fail to heal kindly, and so produce the same result as the deeper lesions—at least so far as our subject is concerned.

Septic absorption is, without question, a far more frequent cause of subinvolution than will be admitted by the mass of practitioners, and a present shame it is, in this age of preventive medicine, that this statement should be true. Not that in every case of subinvolution due to this cause, there should have been a well-marked run of "puerperal fever" so-called; but where antiseptic, or at least aseptic, methods are despised or neglected, nothing is more common than to have, during the first week of convalescence, a rise of two or three degrees in the temperature (commonly called milk fever), the presence of fetid lochia, and moderate abdominal tenderness. In many of these cases there is set up a sufficient degree of uterine or periuterine inflammation to interfere seriously with the process of involution; and if this be true of these mild cases, much more surely will subinvolution follow the more marked instances of septic intoxication. Given a case of puerperal septicæmia, and subinvolution may be confidently predicted.

The next cause to receive attention ought perhaps to have been given precedence over the last. It is the faulty management, or rather the mismanagement, of the period of convalescence; and by mismanagement I mean the permission of too much freedom in movement and of too early rising. I am well aware of the fact that patients are not only allowed to be up and dressed before the end of the first puerperal week, but that such a course is even advised by men who are otherwise safe and skilful practitioners and good observers. That the reasons they give for such a custom have some weight is not denied, but it is far from true that the custom is either a safe or a desirable one. The general weakening and loss of tone of the muscular system, due to a stay in bed of three weeks' duration, is far more than compensated for by the complete rest of the nervous system and the diminution in size of the soft and heavy uterus. The emptying of the uterus and vagina of clots and lochial discharge can be better accomplished by ergot and a douche, than by sitting up upon a chamber vessel or chair, as advised and practised by Goodell, and without the danger of the latter course.

J. T. Johnson,[6] referring to the fact that the colored women of the South who rose quickly after labor are supposed to prove not only the lack of danger, but the benefit of the custom, gives the result of his experience at a Freedmen's hospital, after the late war, in the following words: "Patients suffering from the effects of subinvolution, uterine displacement, and hæmorrhage, presented themselves more frequently than for any other ailments." "While some women are undoubtedly benefited by an earlier sitting up than the customary nine days, . . . many women, and perhaps the majority, are injured by it."

The way in which subinvolution is caused by early exertion, and especially by a too speedy assumption of the upright posture after labor, is by the production of displacement of the uterus, prolapse, version, or flexion, and consequent interference with the local circulation, and hence, with the process of fatty change and absorption. The uterus remaining large, the displacement continues and increases, the hyperæmia is perpetuated, and the chronic changes already outlined proceed to their full accomplishment. By far the safest course is to take conservative ground, and insist upon a sufficiently prolonged rest in the horizontal posture to permit of a near approach of the uterus to its normal size, and then to make a gradual and cautious return to the ordinary habits of life. The rule of Tarnier is a good one, and certainly does not err on the side of conservatism. Provided the uterus cannot be felt above the pubes, the lochia are no longer bloody, and no fever exists, he permits his patients, between the fifteenth and twentieth days, to be moved to a reclining chair where at first they remain only one hour. Lengthening the time by one hour daily, in three or four days they are ready to try a few steps, and so gradually to gain power to walk without fatigue or injury.

Very painful and tedious labors, by leaving the patient in a state of complete exhaustion from which recovery is slow and uncertain, are probably not infrequently the cause of subinvolution. In this case there is a lack of tonicity in the vessels, the active process of removing the waste and building up the new uterus is imperfectly carried on, a passive hyperæmia persists, and the disease is gradually developed. Severe hæmorrhage, either before or after delivery, would act in the same way, by lowering the vital powers and by diminishing the oxidizing properties of the blood.

Various other causes have been suggested, such as incomplete emptying of the uterus at the completion of labor, the presence of tumors in or about the uterus, and sexual excitement due to too early intercourse, or even to sharing the same bed by husband and wife. This latter cause has doubtless caused not a few cases of puerperal hæmorrhage, and can therefore be suspected of setting up a sufficient amount of pelvic congestion to render subinvolution liable.

As predisposing causes may be mentioned a poor state of health from whatever cause, frequent and rapidly recurring pregnancies, and abortions.

Frequency.—For some years after Simpson first called attention to the "Morbid Permanence of the State of Puerperal Hypertrophy," occasional cases were reported from various quarters, but the condition was considered as an infrequent sequel to pregnancy. Of late years, however, with improved methods and more exact knowledge in the matter of gynecological diagnosis, subinvolution is found to be one of the commonest of the morbid results of child-bearing. If it be true that the above-mentioned causes are apt to produce a "morbid permanence of the state of puerperal hypertrophy," then it is by no means to be wondered at that subinvolution is a frequent condition among parous women. It is impossible to give statistics of any value on this point as, in the nature of the case, they must vary materially in the practice of different men, in hospital and private practice, also because of the confusion in nomenclature and classification.

The condition once established, from whatever cause, it tends to the more intractable, and oftentimes incurable, disease already referred to as chronic metritis, or areolar hyperplasia; hence the importance of the early recognition of the danger, that the cause may be removed and complete involution secured at the proper time. This point will receive more particular consideration under the head of treatment.

Symptoms.—The symptoms of subinvolution are, as a rule, vague, and rather suggestive than indicative. Commonly backache and a tired feeling, either continuous or arising upon slight exertion, first call attention to the existing trouble. Often such patients come desiring some simple tonic, hoping thus to escape their feeling of lassitude. Menorrhagia and metrorrhagia, much less frequently amenorrhœa, are apt to be present, the former being at times so excessive as to produce a profound state of anæmia, and even threaten life. When this occurs it is usually a result of the coexisting disease of the endometrium. Dysmenorrhœa by no means always exists, though it is frequently present. If the uterus is very large, symptoms arise from the mechanical effect of pressure, such as difficult or painful micturition, constipation, and hæmorrhoids. Pain may be experienced in more remote parts, as in the thighs, calves of the legs, under the breasts, or in the head.

On examination, the uterus is found to be uniformly enlarged and, if the disease be of recent development, softened. The cervix is commonly lacerated, the canal large, sometimes even admitting the finger. Pain is not so marked as later in the course of the disease, yet firm pressure anywhere upon the uterus shows it to be much more sensitive than normal. On account of the increased weight of the organ it is partially prolapsed, often resting upon the floor of the pelvis, or in a position of retroversion.

Diagnosis.—It is by no means a simple and easy matter to make a positive diagnosis in any given case, unless the patient has been under continuous observation since the pregnancy from which the condition dates, for the reason that the term is rather expressive of a clinical fact than of a pathological process. The uterus may have undergone a perfect involution, the hypertrophy developing subsequently as a result of an endometritis, of a displacement, or of ovarian disease. A probable diagnosis may, however, be made in most cases by a careful comparison of the symptoms and physical signs, the former having dated from a previous confinement or from a period not long thereafter.

On account of the softness and moderate sensibility of the uterus in many cases, it may be mistaken for pregnancy in the early weeks, or vice versa. In case of doubt, it is far better to wait for time to indicate the true diagnosis than to run the risk of producing abortion by passing the sound. This word of warning is not an idle one, for the accident has often happened to the impatient and thoughtless, and should be guarded against by excess of caution. It is not impossible that the two conditions may coexist; hence arises additional cause for care.

In view of the uncertain relations existing between subinvolution and chronic metritis, and because, if they be separate diseases, the treatment of each is the same, it is hardly worth while to attempt a nice discrimination. If the disease be subinvolution pure and simple, with no metritis or "perivascular sclerosis" grafted upon it, the uterus will be softer and more doughy than normal, will measure three inches or more in depth, and pressure upon it will be easily borne. Where there exists the condition described as chronic metritis or areolar hyperplasia, the uterus is hard and sensitive; there is usually more or less constant pain in the hypogastric region. The uterus is movable in both instances, unless there be adhesions or accompanying perimetritis.

Fibroid tumors increase the bulk of the uterus and elongate its cavity, but they can almost always be felt as local enlargements of the uterine mass, or at least the enlargement is not uniform. The history of the case will usually fail to show any causative relation of pregnancy. The appearance of the cervix will often be of assistance, it being usually of normal size and density in the case of tumors wholly confined to the uterine body. Malignant disease confined to the body might be mistaken for subinvolution on account of the tendency to hemorrhage, the uniform enlargement, the lack of pain, and the absence of sensitiveness commonly noted in the early months. The age of the patient, the continual presence of a watery discharge, and sometimes the offensive odor, together with the wasting strength, should suggest the nature of the disease, and microscopic examination of shreds removed by the curette will determine it.

Prognosis.—The prognosis of simple subinvolution which has not yet progressed to the sclerotic stage is good, provided suitable treatment be adopted. Untreated, its tendency is to run through the several stages of fibrous deposit, induration, contraction, atrophy. Under these conditions its course is very variable, being influenced by a great number of factors. In some instances the complete course outlined above appears to have been run through inside of a year, yet on the other hand there are cases which seem to remain almost stationary for years. When the stage of fibrous infiltration has been reached—and most cases presenting themselves for the relief of symptoms have already entered upon it—the prospect of complete cure and restoration to the normal is poor. As a rule, the most that can be expected is the relief of the principal symptoms, partial reduction of the existing hypertrophy, and the avoidance of more serious complications. The uterus may also be placed in a more favorable condition for the occurrence of pregnancy, and for its successful completion.

Treatment.—To a very considerable extent subinvolution is preventable, and hence prophylactic measures should be first considered and uniformly practised. It is unnecessary to urge the importance of seeing to it that every woman approaches her confinement in the best possible state of health. Of course existing disease will be combated and removed so far as possible, but let the physician also set his face against every depressing influence so often invoked by women to diminish the size of the fœtus and so insure an easier labor. Let good food, fresh air, and plenty of exercise be invoked to aid in establishing or continuing a condition of vigorous health previous to delivery.

The importance of insisting upon a recumbent posture and absence of effort during the first two weeks, and upon a gradual and cautious getting up after labor, has already been referred to.

Septic causes having much to answer for in the production of the disease in question, they must by all means be guarded against. And with the present light upon the subject of antiseptic midwifery, there is no excuse for the man who neglects such simple precautions as are universally agreed upon. In this connection Goodell[1] says: "The day is surely coming when to have a case of puerperal fever in one's private practice will be deemed a crime."

Tedious and very painful labors being, by their exhausting influence, potent factors in causing or at least in favoring the occurrence of subinvolution, they should be avoided so far as possible by the use of forceps and of the various anæsthetic agents. Chloral during a long first stage is capable of giving rest and relief from pain, with proportionate lessening of exhaustion. Ether and chloroform properly used are perfectly safe, can be given, if necessary, for long periods without material delay in the progress of labor, and even with the effect of shortening the duration in many cases, with diminished rather than increased risk of hemorrhage, and with the result, in almost every instance, of great relief of suffering, a minimum of fatigue, more speedy convalescence, and more rapid and certain involution. There is no need of commendation of the forceps, yet, bearing in mind the baneful influence of an unnecessarily prolonged second stage, no mere prejudice against operative interference should be permitted to prevent the timely employment of this means of abridging wear and tear.

Lacerations of the cervix having been shown to result almost inevitably in subinvolution, it follows, as a corollary, that the presence of such tears should always be sought for after labor, in order that this and other possible consequences may be averted by suitable treatment addressed to the lesion. Conversing with a successful fellow-practitioner recently upon this subject, I was assured that not one physician in a hundred makes a practice of examining his patients during or at the close of the puerperal month, and that such a custom is uncalled for. If this belief is general and the former assertion correct, and I believe them so to be, the frequency of subinvolution is to a large extent accounted for. He is a bold man who will fly in the face of such unanimous testimony as now exists to the contrary, and assert that laceration of the cervix is not liable to result in subinvolution, or that it matters not if it does, as the latter condition is one of no importance; yet one of these positions must be taken by the man who disbelieves in the practice of examining his puerperal patients before permitting them to pass from his hands. Unless some special symptoms seem to demand interference, it is well not to examine until after the completion of the second week, and better still is it to wait until the close of the third week, or even of the puerperal month. By this time involution should be well advanced, and the cervix should have returned nearly enough to the normal to enable one to judge well as to the extent of any laceration, should one be present. The treatment of such lacerations needs no consideration here, that having been fully covered in another article; but the importance of caring for them at once cannot be too strongly enforced.

In making the examination as recommended, any other existing condition which may serve as a possible cause of trouble can be noted and receive due attention. It is taken for granted that any rupture of the perineum has been previously sutured, but the success of the operation is now to be assured. If the uterus is displaced, it must now be returned to its normal position and sustained there by glycerine tampons or a pessary.

When subinvolution is discovered soon after labor, simple removal of its causes will usually suffice for a cure. Later on, when the patient applies for treatment for the relief of symptoms, the problem is by no means so simple. Measures directed toward the elevation of the general tone of the system are always called for. Tonic remedies, liberal diet of the right sort, general sponging followed by brisk rubbing, and, in those cases in which suitable exercise cannot be taken, the employment of massage, are to be advised. Having at the same time removed all existing local conditions which may serve to perpetuate the disease, our efforts must be turned more directly to the removal of hypertrophy and restoration of function of the diseased organ.

In almost all cases there exists hyperæmia, which is, indeed, the important element in the continuation of the trouble. This should be attacked by puncture, scarification, or, better still, by the application of leeches to the cervix, and by the use of glycerine tampons and hot douches. The latter must be given properly in order to be of any value, the position being on the back with hips raised, the water not cooler than 110° F., and the duration of the douche not less than fifteen minutes. Painting the cervix with Churchill's tincture of iodine can do no harm, and is often of great benefit. In those cases in which the cervical canal is patulous, and active endometritis is absent, the application of iodized phenol to the uterine cavity by means of an applicator is of marked utility. Such an application should be made about once a week.

Electricity is highly recommended by many writers of recent years, and has given good results where other means have been tried in vain. Both the galvanic and faradic currents are of value, either separately or in combination. The faradic current is chiefly applicable, in recent cases, to promote contraction of muscular fibre and diminution of hyperæmia by the resultant emptying of the venous circulation. The galvanic current finds its most important application in the later cases, in which fibrous deposit has already taken place. Galvanic stem-pessaries have been recommended, but not being altogether safe, and being of rather doubtful utility, they have never found much favor. They can probably be dispensed with.

Not infrequently there coexists with, or springs up in consequence of, subinvolution, a condition of hyperplastic endometritis, which is largely accountable for the hæmorrhagic symptoms. In such cases it may be necessary to remove the diseased membrane by the use of the sharp curette, following it, in intractable cases, by the application of tincture of iodine, or even of iodized phenol. This, of course, is to be regarded as a surgical operation, strict antiseptic precautions being observed, and the patient being confined to bed for several days thereafter.

In some refractory cases of subinvolution, operative interference has been practised by Reamy and others, in "removing a wedge-shaped piece from the cervix, and closing the rent with sutures as in trachelorrhaphy, . . . when laceration of the cervix did not exist." Good results are reported from this operation.

Subinvolution of the Vagina.—In the vagina, as in the uterus, the process of hypertrophy and development continues throughout pregnancy, to be followed after delivery by a process of involution almost identical in its method and purpose with that which occurs in the uterus. By this means the vagina is restored, in about two or three months, very nearly to its normal nulliparous condition, remaining permanently, however, a little larger than before. This perfect result is, unfortunately, by no means always accomplished, and subinvolution of the vagina is, like subinvolution of the uterus, of common occurrence.

The causes of incomplete involution of the vagina are, for the most part, those that have already been assigned as factors in the production of uterine subinvolution, the latter almost always being accompanied by more or less vaginal subinvolution. The cause which most uniformly and certainly interferes with the process of involution in the vaginal walls is, without doubt, laceration of the perineum or pelvic floor. While laceration of the perineum in its entire thickness is common, laceration of the posterior vaginal wall, together with the inner portion of the perineal body, is, if possible, a still more frequent accident, and is followed by more disastrous results. When a rupture extends through the fourchette, and even more deeply into the skin of the perineum, the injury cannot fail to be noticed by the most casual observer; but when internal inspection is necessary to disclose the rent the chances are strongly against its discovery. The average physician considers his duty done when he inspects the perineum externally, and to his great satisfaction finds that "not even the fourchette is torn," forgetting or not knowing the fact, so strongly insisted upon by Mathews Duncan, that the point at which laceration usually, and in primiparæ almost inevitably, begins is at the ostium vaginæ, not at the ostium vulvæ—at the plane of the hymen, not at the fourchette. In examining the perineum after labor, therefore, look carefully to the mucous surface.

Prophylactic methods of treatment will be the same as outlined above for subinvolution of the uterus, especial stress being laid upon the care of the perineum both during and after labor. Curative treatment, after known or possible factors in the production of the disease have been removed, will consist in the use of douches, occasional applications of iodine, with insertion of glycerine and alum tampons, and the employment of electricity. While both the faradic and galvanic currents are of utility, and many prefer the latter, my own preference is strongly for the former. By using a bipolar electrode active contraction of the muscular fibres is brought about, their tone is thereby improved, passive hyperæmia is removed, absorption is stimulated, and the uterus is more firmly supported.

Operative interference is often called for to repair old injury to the perineum or cervix, to remove cystocele and rectocele, or to narrow and shorten a redundant vagina, which, by the simpler means mentioned, cannot be reduced to the normal.

SUPERINVOLUTION.—Nominally superinvolution is an excess of involution, by which the uterus is reduced to less than its normal size, yet it is an open question whether just this process really occurs. Undoubtedly cases are noted, and with increasing frequency, in which, at some time after the completion of puerperal convalescence, the uterus is found in a state of atrophy; but is this atrophy due to excess of the normal process with failure in the regeneration of muscular fibre, or is it rather fibrous contraction following upon actual inflammation or occurring as a sequence of subinvolution, or is it even a result of disease of the ovaries by which their function is destroyed, and hence corresponding to the senile atrophy of the menopause? The present attitude of the profession toward this disease is one of observant scepticism. It is too soon for anyone to assert dogmatically that superinvolution, pure and simple, does not exist; yet before making that diagnosis in any case it would be well to consider carefully if there be not some other disease, of which the atrophied uterus is merely an expression or consequence. Even the classical case of Simpson—the case which first suggested to his mind the title under consideration—is more likely one of premature atrophy and cessation of function due to tubercular disease.

But whatever opinion may be held concerning the accuracy of the term, it must be admitted by all that uterine atrophy does occur, without apparent cause, in a certain number of cases, not long subsequent to delivery, and to this condition has rightly or wrongly been given the name superinvolution. That the condition is a rare one is shown by the scarcity of reported cases, and by the fact that most writers upon the diseases of women ignore the subject completely.

As regards the pathology of superinvolution, it can only be said that the uterus resembles that organ in a state of senile atrophy. Observations are too few to afford any definite information concerning the morbid processes involved.

There are no distinctive or constant symptoms which belong to the disease, with the single exception of amenorrhœa, or scanty menstruation. Besides this, there is the ordinary train of symptoms common to many another form of uterine disease. Examination reveals simply a non-sensitive uterus, of less than the normal size and depth. The ovaries, if found at all, are commonly much smaller than normal, and are not infrequently bound down and compressed by adhesions.

The disease is a very intractable one, though the prognosis will vary in accordance with the pathological conditions which stand in causative relation to the atrophy. In some cases, diagnosticated as superinvolution, a cure has been achieved and pregnancy has followed, but it may be laid down as a fact that most cases will prove absolutely rebellious to treatment and sterility will be permanent.

The only treatment which has been found of value is one having for its purpose stimulation of the uterus, and this is best accomplished by the combined use of moderate cervical dilatation and electricity. Either a Hanks or a steel-branched dilator may be used to stretch the cervix slightly every week or ten days. Rockwell recommends that both the faradic and galvanic currents be utilized, and relates one case in his own practice in which menstruation was thus induced in a uterus measuring but one and three-quarters inch. The poles of the faradic battery may be used indifferently, but when employing the galvanic current he advises that the negative pole be placed within or against the uterus.

Rufus A. Kinsman.

UTERUS, PROLAPSE OF THE.

The subject of uterine prolapse, embracing as it almost necessarily does a consideration of hypertrophic elongation of the cervix and prolapse of the vagina, is very complicated. Before considering it in detail, it will be necessary to define as clearly as possible what the normal position of the uterus is, and how it is maintained. Under normal circumstances the uterus is supposed to occupy a position of anteversion, the fundus resting upon the bladder, and the cervix pointing backward toward the tip of the coccyx; it is kept from sinking by the resistance offered from below, and by certain ligaments of which I shall speak very briefly. The broad ligaments are folds of peritoneum, which divide the pelvic cavity into two parts, an anterior and a posterior, and which cover the body of the uterus, passing outward and backward to the sides of the pelvis; these ligaments contain connective tissue, vessels, nerves, and muscular fibres. The utero-sacral ligaments are folds of peritoneum containing muscular fibres and connective tissue; they pass outward and backward, from the body of the uterus toward the second sacral vertebra. The utero-vesical ligaments are formed by the peritoneum as it passes between the uterus and bladder. Lastly, the two round ligaments extend from the external abdominal ring to the anterior and superior part of the uterus. The vagina is a mere slit in the pelvic diaphragm running from the hymen to the cervix uteri, to which it is firmly attached; the anterior and posterior walls are in apposition forming the **H** appearance spoken of by Henle; it is firmly attached to its neighboring organs and in front to the pubic arch. The fundus of the uterus enjoys almost perfect freedom of motion, rising and falling with a full and empty bladder, the ligaments limiting excess of motion only. Savage, in experimenting on artificially produced prolapse, a vulsellum being attached to the cervix and traction made in the direction which the uterus would take, found that about one and a half inch of descent could be accomplished before the ligaments offered resistance; then the utero-sacral ligaments became tense, but there was no sign of strain upon the broad or round ligaments. When these utero-sacral ligaments were severed, the uterus yielded about one inch more, and when the broad ligaments together with the subperitoneal cellular tissue were divided, complete prolapse resulted.

Prolapse of the uterus may be complete or partial. It is called complete when the fundus lies below the pelvic outlet.

By far the greater number of cases of prolapsus uteri date from the puerperal condition, though it may occur at any age, and in the virgin. Monro reports a case in a child three years of age. Cases of congenital prolapse have been spoken of, but are not described with sufficient detail.

Out of 174 cases collected by Wanley, there were only 6 occurring in women who had not had children. Winckel thinks that most cases of prolapse occur between the twenty-fifth and thirty-fifth years of life.

A deformed (kyphotic or spondylitic) pelvis may be the initial cause of prolapse, as may also be a very roomy pelvis. In the first case the uterus does not find space sufficient for its accommodation. Veit reports the case of a girl, fourteen years of age, who had a kyphotic pelvis and prolapse of the uterus. Long and exhausting sickness, such as typhoid fever, cholera, or phthisis, may lead to such a diminution in the amount of the fatty tissue which normally surrounds the uterus that the organ, deprived of this support, sinks down. Senile atrophy may lead to the same result. Increase in the intra-abdominal pressure, caused by long-continued coughing, straining at stool, and tight lacing, may cause prolapse. Dr. Dickinson has called attention to the increased bulging of the pelvic floor due to tight lacing; he finds that this harmful practice increases the projection more than one-third, and believes that when a large number of cases are collected he can show "that it is those women having roomy pelves, or pelves of less inclination than usual, whose pelvic floors sag most under pressure from above." He thinks that the uterus must descend with the structures above it. With a quite tight corset the displacement is one-third of an inch; this seems a very small descent; but when we consider the other factors spoken of above as producing an increase in the intra-abdominal pressure, namely, coughing and straining at stool, it is quite easy to see how this displacement can be much increased. Engel states that in every one of thirty autopsies in which evidence of tight lacing was found, prolapse was present to some degree, except where adhesions had prevented it.

Heman and Skene were the first to call attention to an undue bulging of the pelvic floor and diaphragm; they found the average displacement to be about four inches, but in some cases it amounted to more than six.

Change of position must, with the exception of the undue bulging just spoken of, precede prolapse; that is, the long axis of the uterus must come more and more to correspond with the long axis of the vagina. The cervix approaches the anterior vaginal wall, and a position of retroversion is established. Prolapse may occur suddenly after lifting some heavy object, after receiving a blow upon the abdomen, and after a fall. Anything tending to make an open canal of the vagina favors prolapse of its walls and so leads to descent of the uterus. Pessaries which stretch the vagina, masturbation, which, it is claimed, causes a loss of tonicity in the tissues, and individual peculiarities of tissues all tend to make a normally closed canal an open one, and so favor prolapse. During labor the vagina becomes an open canal or a yielding medium, and remains so for some time after birth, and the uterus is always found prolapsed immediately after the termination of labor. The vaginal walls begin to curve inward, and the parts above, deprived of this support, sink down; the peritoneum has been very much stretched and lies in folds around the uterus, only to regain its firm tone through time. If now we add to this a torn perineum, and a uterus whose normal involution has been interrupted through metritis and poor nutrition, we have all the conditions for the production of prolapse. These are a heavy uterus with lax ligaments, whose position may have changed, so that the long axes of the uterus and vagina are beginning to correspond or

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[1] Transactions of the American Gynæcological Society, 1879, 1881, 1882. [2] William Wood & Co., 1886, vol. ii., p. 8.
[3] Second edition, p. 719. [4] American Journal of Obstetrics, 1885.
[5] Diseases of Women, second edition, p. 467.
[6] Transactions of the American Gynæcological Society, vol. ii., p. 307.
[7] [illegible], [illegible] edition, p. 511.

do correspond; a prolapsing anterior vaginal wall, not finding the support to which it is accustomed on the perineum; and a dilated vagina whose walls may have suffered some rupture. Very prolonged labors and obstetrical operations have been supposed to be the antecedents of prolapse.

Hypertrophy of the fundus and cervix of the uterus, as well as tumors situated in the organ, *e.g.*, subserous fibroids and polypi, may so increase the weight of the uterus as to cause it to prolapse, the ligament and collum of the vagina no longer being able to support the heavier burden.

Abdominal tumors, whether or not attached to the uterus, may force it downward, or, on the other hand, they may form adhesions, and thus prevent prolapse. Ascites may displace the organ downward. The anterior vaginal wall may be prolapsed as the result of the presence of a tumor between the bladder and vagina, or of a cyst, and so indirectly lead to prolapsus uteri.

Fritsch has never seen a case in which primary prolapse of the posterior vaginal wall was the inciting cause.

Hypertrophy of the cervix, as already said, may be divided into infra-vaginal and supra-vaginal. Huguier drew attention to this condition, and said that most cases of prolapse originated from this cause. In the infra-vaginal variety the cervix rarely attains a length greater than that of the vagina. This form of hypertrophy appears to be due to greater nutritive activity; and most of these cases are traceable to the traumatisms of labor, or to defective involution. Fritsch thinks this hypertrophy is caused by displacement reducing pressure on the cervix, and so predisposing to greater activity and growth. The posterior lip of the cervix is very often hypertrophied, and has been called tapiroid, from its resemblance to the snout of a tapir. The pathology of hypertrophy of the supra-vaginal part of the cervix is a much disputed subject.

Goodale gives four of the theories advanced so concisely that I cannot do better than quote from him.

"(*a*) That the primary affection is a downward growth, a true hypertrophic elongation of the supra-vaginal portion of the cervix; and that the prolapse of the vagina and bladder is secondary, being the necessary result of the former.

"(*b*) That there is no change of structure in the cervix other than the strictly mechanical one of elongation, which is a secondary accident, consequent upon the traction exerted by a primary prolapse of the vagina and bladder.

"(*c*) Martin's, that the circular hypertrophy of the vaginal portion of the cervix, of which the eversion of the os is the result, is a disease, *sui generis*, and that it constitutes the weight which lengthens out the supra-vaginal cervix.

"(*d*) Isaac E. Taylor's, that, contrary to the commonly accepted belief, the glandular portion of the cervix during gestation is not effaced but hypertrophied, and that even after labor it still exists; for it has undergone nothing more than a momentary expansion of its canal for the passage of the fœtus; that consequently, if the natural process of involution does not take place, the gravity of this hypertrophied cervix will aid and sustain the elongation of the non-glandular part of the supra-vaginal cervix, namely, the isthmus, which is thick, soft, and ductile, in the non-involuted womb."

Savage thinks that there are no cases in which the two varieties of infra- and supra-vaginal hypertrophy exist in the same subject.

The conjunction of the theory of traction with that of ductility, traction from the prolapsing bladder and vagina, ductility from a chronic congestion of the womb, "offers a very reasonable explanation for the phenomena of uterine elongation." Winkle records 9 cases, in 1,618, in which the cervix had descended without displacing the vaginal walls.

The lower half of the anterior vaginal wall usually begins to prolapse, and with this is generally associated a condition of beginning prolapse of the bladder, and cystocele; the remaining portion of the anterior wall follows, with prolapse of the uterus later. Martin speaks of one case in which the prolapse began in the upper third of the anterior wall, and was due to a coil of intestine lying between the bladder and the uterus; it is very rare for a prolapse to begin by the bulging out of the posterior wall. A rectocele is of comparatively rare occurrence, the posterior wall usually freeing itself from the rectum, and prolapsing without it. Winkle speaks of 108 cases of prolapse of the uterus, of which 54 were associated with cystocele; rectocele was found, however, in only 33 cases.

In complete prolapse, the uterus may be either anteverted or retroverted, there is a prolapse of the vaginal walls, and complete or partial prolapse of the bladder, associated in rare cases with rectocele. The cervix may be found hypertrophied as a whole, or only its anterior lip, or the long hypertrophied cervix may be seen projecting through the vulva and felt inside with no displacement of either vaginal wall, and with the fundus uteri in very nearly its normal position.

The peritoneum usually becomes displaced with the uterus, and occupies relatively the same position that it did with the uterus normally situated in the abdomen. This relation of the peritoneum to the prolapsed organ should be carefully studied.

The symptoms of prolapsus uteri vary exceedingly. As a rule, the condition comes on slowly, occupying from a few months to a year or two in forming, and giving rise to symptoms which will be mentioned later. On the other hand, there may be great pain of a tearing character, nausea, vomiting, suppression of urine due to compression of the ureters, or loss of consciousness. Peritonitis and death may occur in other cases, although the prolapse is sudden and little complaint is made. The sudden strain to which the peritoneum is subjected accounts for the acute pain. In cases in which the prolapse occurs slowly there may be pain during defecation, dysuria, backache, and a feeling as though all the contents of the pelvis were falling out, a feeling of great fulness in the vagina, and symptoms associated with backward displacement of the uterus. Incontinence of urine Winkle found to exist in only one per cent. of his cases. Any cause which serves to change the intra-abdominal pressure, causes pain, as using the arms, etc.; standing, walking, and going upstairs are very disagreeable to the patient. If prolapse is complete the patient walks with a straddle. Menstruation may be normal, but as a rule it is scanty. Conception is possible, and one case is recorded in which the fully prolapsed uterus became pregnant.

Coition has been known to take place through the uterine orifice. Leucorrhœa is usually present when the prolapse is complete, and we may also find ulceration and erosion, which take a long time to heal. Fritsch calls attention to the rarity of malignant disease developing in a prolapsed uterus. Gangrene may occur. Adhesions between the intestine and the pelvic organs may make reposition impossible.

Diagnosis.—Only in cases of beginning prolapse is the diagnosis difficult, the patient usually, in cases of long standing, making a correct diagnosis without the aid of a physician.

Backache and bearing-down pains are usually complained of. A digital examination establishes the position of the uterus; the cervix will be found pointing toward the anterior vaginal wall, and the whole organ lower down than normal. Coughing and bearing down will force the uterus nearer the pelvic outlet, because of the increased intra-abdominal pressure, and this will help to confirm the diagnosis. If the case is far advanced when seen, the anterior vaginal wall will fall out when the patient bears down, and the posterior wall will be found, as a rule, to have descended with the uterus, which now occupies a much lower position in the pelvis. At the vaginal orifice the long axis of the uterus corresponds with the axis of the vagina, the cervix appears, then the fundus, and prolapse is complete. Cystocele will be easily recognized by introducing a sound into the bladder; likewise a finger in the rectum will inform us whether or no there is a rectocele. The relation which the vaginal walls bear to the uterus should be noted, to see whether the whole vagina has been inverted; if it has not been, then the positions of the anterior and posterior vaults should be ascertained. After excluding pregnancy, a sound can be passed into the uterus, which will tell us the length of the cavity, and by feeling carefully the sound as it passes the internal os, we can determine how much of the depth is due to hypertrophy of the cervix in those cases in which the uterus is found larger than normal. One or two fingers introduced into the rectum, the other hand upon the abdomen, will give us information regarding the position of the fundus. If the prolapse is not complete, reposition should be tried, first of the anterior vaginal wall, then of the bladder, and eventually of the uterus.

The position of the uterus in the abdominal cavity should now be noted. The walls of the organ should be carefully palpated to see whether they contain a tumor, whether they are hypertrophied, and also to determine their consistency. Prolapse of the uterus should be differentiated from a polypoid myoma and from inversion.

Much may be done in the way of prevention of prolapse. A too early getting up after labor, thereby permitting a heavy uterus with lax ligaments to rest upon a distended vagina, should not be allowed. The formation of a cystocele, occurring as a result of an over-distended bladder should be prevented by the use of the catheter. If the perineum has been ruptured during labor, it should be repaired immediately. Lying upon the back constantly should not be allowed, as a condition favorable to retroversion is thereby maintained, but change of position, Fritsch thinks, should be insisted upon. Any backward displacement of the uterus should be corrected at an early date. If the vagina is found in a relaxed condition, astringent injections are called for, or the astringent can be introduced upon pieces of cotton. Violent exercise after leaving the bed should be forbidden, and care should be taken to have a regular movement from the bowels daily.

In beginning as well as in advanced, prolapse support may be given to the uterus by means of pessaries. Ring pessaries have been much used for this purpose; they are made of hard or soft rubber. The last-named variety appears to be the best. The disadvantage of this form of pessary is that the vagina becomes very much stretched by its use, and a larger size is needed every few months. The Hodge or Albert Smith pessary may be used, and sometimes the instrument gives much relief. Very many other kinds of pessaries have been used, but treatment of prolapse by this means is gradually giving way to operative treatment, which promises more permanent relief, and is attended with very little danger. Packing the vagina with cotton will sometimes keep a prolapse back, and has this advantage over support by a ring pessary that the vagina is not so much distended. A T bandage is worn in such cases. Professor F. Von Preuschen has quite lately reported three cures of prolapsus uteri treated by Brandt's gymnastic method. This consists in first pushing the uterus well up into a position of anteversion, when an assistant holds the uterus anteverted by means of a finger in the vagina, and the operator seizes it with the appendages and pushes them toward the umbilicus; this is repeated three times, the assistant seeing that the uterus does not become retroverted. Next, the knees of the patient are brought close together, and she is instructed to resist the force used to separate them; when they are thus separated, she is again told to resist the force used to bring them together; after this the sacral and lumbar regions receive a certain amount of tapping executed with the hand. The recorder of the cases thinks that the action of the adductors causes the levator ani to contract, and that this is most important; the whole muscular floor of the pelvis is, however, made in this way to contract. The following are the three cases in brief:

1. Woman, aged twenty-nine, with complete prolapse. Treatment began on April 18th, and lasted till June 2d, when she was pronounced well. The uterus remained in position after the first manipulation.

2. The external os was seen surrounded by the vagina. First treatment April 20th, ended July 1st, when the uterus was found to be in very good position.

3. Woman, seventy-one years old. Total prolapse. Treatment began on June 5th, and the patient remained till July 10th. The uterus remained in place after the first treatment.

These few cases reported appear to have had a most successful termination.

The whole uterus has been removed for prolapse a number of times. Saenger, Winiwarter, Martin, Leopold, and Thomas, have each done it. Martin lost his case through septic infection, but the other cases recovered.

The abdomen has been opened and the uterus drawn up and stitched to the abdominal walls. This is not infrequently done when the abdomen is opened for the removal of tumors, etc., but, as an operation for prolapse, it has not yet become very popular.

A ruptured perineum should be repaired by some one of the many plastic operations recommended.

Lacerations of the cervix should be attended to, and if there is much hypertrophy of this part of the uterus it should be amputated. For this purpose the cold-wire écraseur, the galvano-cautery, and the knife have been used. The first two methods leave a raw surface, which has to heal by granulation, and the os is in danger of closure. With the knife two wedge-like pieces are removed, one from each lip. A rubber ring or piece of rubber tubing is placed around the cervix to prevent hemorrhage; the cervix is split into an anterior and posterior lip. Each lip is then amputated separately, the flaps are brought together by wire suture, the vaginal and cervical mucous membranes coming together. Particular attention should be paid to the relation which the bladder and posterior vaginal fold bear to the hypertrophied cervix. The bladder, as well as Douglas's pouch, have been opened by this operation without bad results, though, of course, it is an accident to be avoided.

The Alexander-Adams operation for shortening the round ligaments of the uterus, and so bringing the organ into place, has found much favor lately.

The other operations aim at narrowing the vagina, arching it forward, and strengthening the recto-vaginal septum. Stenosis of the vagina has been produced in many ways by the use of nitric acid, chloride of zinc, and the actual cautery. Strips of mucous membrane have been removed from either the anterior or the posterior surface of the vagina, and the denuded surfaces brought together. The vagina is to be carefully washed out with a solution of carbolic acid or corrosive sublimate; then the line of operation is mapped out on the vaginal wall, and the mucous membrane is removed, the denuded surfaces being united by means of silk and catgut sutures, some deep, others superficial. They should all be introduced before any are tied, and are to be allowed to remain in place for from twelve to fifteen days. Hegar's operation is probably the most popular. Winkle has delivered women, after this operation had been done, without injury to the vagina.

Anterior or posterior colporrhaphy, together with amputation of the cervix, can be performed at one and the same time.

George Haven.

VESICO-VAGINAL FISTULÆ. A fistula is an abnormal communication through the tissues between two organs or passages, or between an organ or passage and the exterior of the body. The course of the communication may be either direct or tortuous. A vesico-vaginal fistula is such a communication between the bladder and vagina by means of which the urine constantly or spasmodically makes its escape.

These urinary fistulæ are classified according to their location as follows: I. Vesico-vaginal fistula (proper). This is situated in the vesico-vaginal wall and involves only that tissue. II. Vesico-utero-vaginal fistula. This comprises cases in which the tear reaches up to, or dissects off the vesico-vaginal tissue from the uterus, and necessitates the passage of the suture through uterine tissue in the repair. III. Vesico-uterine fistula. In these cases the vaginal wall is intact, the bladder communicating with the uterus and the urine thus finding its way through the os into the vagina. IV. Urethro-vaginal fistula. This is applied to cases in which an opening exists in the base of the urethra, through which urine escapes into the vagina. But this can only occur during the act of micturition. V. Uretero-vaginal fistula. This is the rarest form of fistula. It is the result of an extensive tear or loss of tissue by means of which the ureter is involved. Dr. Emmet claims that this lesion is more commonly the result of a pelvic abscess. During the inflammatory process the ureter becomes occluded by pressure, perforation ensues, and the urine finds its way into the vagina.

The most common location of a vesico-vaginal fistula is in the median line and directly behind the symphysis pubis. The usual form is oval, linear angular, or round. The most common is the oval, due, as Dr. Agnew explains, to the superior contractile power of the longitudinal over the circular muscular tissue of the vagina. These fistulæ vary in size from an opening so small that it is found with great difficulty and admits only the smallest probe, to those that involve the whole of the anterior vaginal wall, with entire base of bladder and the urethra. One illustration of the latter has come under my own observation and care. In this case there was no trace of urethral tissue whatever. The entire base of the bladder was wanting, and stretching across the common cavity behind the symphysis, and springing from and continuous with the tissue of the recto-vaginal septum, was a strong cicatricial band which reached from side to side of the pelvis, leaving only sufficient room for two fingers to pass with difficulty between it and the symphysis. Through this small opening the inflamed and sensitive fundus of the bladder frequently prolapsed. Such cicatricial bands, of greater or less density and resistance, and reaching across the vagina in the most diversified directions, are a common complication in cases of fistula.

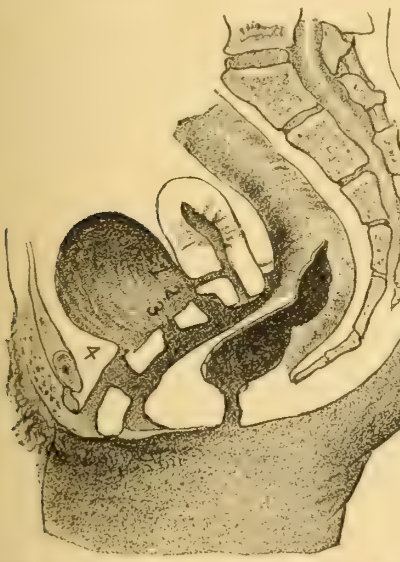


FIG. 5100.—Location of Fistulæ. 1, Utero-vaginal fistula; 2, vesico-utero-vaginal fistula; 3, vesico-vaginal fistula; 4, urethro-vaginal fistula.

Etiology.—The most common cause of urinary fistula is injury due to parturition. If the delivery be premature and rapid, especially when attended with undue rigidity of the soft parts, laceration of the cervix uteri is apt to occur. Especially is this the case in primipara of advanced age, and in cases in which morbid changes have occurred in this tissue. When sufficiently extensive this laceration results in a permanent fistula. The vesico-utero-vaginal and the vesico-uterine are the varieties most often produced in this way. The tear, beginning in a rigid os, extends out upon the vagina or up the cervix to the vesico-cervical junction. In the process of repair this may all heal, with the exception of an opening at the junction of the vagina with the cervix. Or all the tissues below may heal, leaving an opening at the upper angle of the tear—a vesico-uterine fistula.

It is universally accepted now, however, that the majority of fistulæ are caused by the sloughing away of tissue due to severe and prolonged pressure of the presenting part. So long as the pressure is intermittent and not too long sustained at any one time no harm is done; but when impaction occurs and the pressure becomes continuous, circulation is obstructed and the vitality of the soft tissue thus compressed is destroyed. Necrosis occurs, the slough separates, and the urine makes its escape. According to Agnew, over ninety per cent. of vesico-vaginal fistulæ are thus produced, while in Emmet's experience ninety-five per cent. of his cases were the result of prolonged and difficult labor.

When the fistula is produced by laceration the urine makes its escape at once and the condition is immediately suspected. But in cases of protracted labor time is required for the slough to separate, and the urine may not escape for several days. The average time is ten days, but it may occur in four or five and may be delayed for a month. One case that came under my care, when interne in the New York Woman's Hospital, gave a history of retention of urine, following confinement, till the ninth day, when suddenly her bladder burst and a flood of urine was discharged through the vagina. The cicatricial bands, however, which upon examination obscured the fistula, indicated a process of sloughing, and the separation of the necrotic tissue was to her the "bursting of her bladder." An interesting feature of this case might be mentioned here. The fistula was a vesico-utero-vaginal one, rather extensive, and in closing the wound the right ureter was involved in one of the stitches and became obstructed. This was indicated by sharp colicky pain, shooting along the course of the ureter on the right side and reaching to the kidney, attended about every three hours with a sharp spasm of pain and a gush of urine through the catheter that was in the urethra. When this was reported to the operator he refused to interfere with his stitches, maintaining that if the urine had found its way once into the bladder it could do so again, and would continue to do so till a permanent escape was thus established. His prediction proved true and the operation a perfect success.

Ill-adjusted, displaced, and neglected pessaries have been known to ulcerate through the vaginal wall and produce fistula; vesical calculi likewise may ulcerate through into the vagina, leaving a fistulous opening. Urinary fistulæ are also produced by firearms, by rough manipulation of sound or catheter in the bladder, by accidental puncture during operations on surrounding tissue, as in the operation for atresia vaginæ or amputation of cervix uteri in malignant disease, etc. Contrary to former teaching, malignant disease of the uterus in itself almost never produces a vesical fistula. The essential tissue of the bladder is so highly organized, so well nourished, that it is enabled to resist the encroachments of such morbid action. As has been said, however, fistulæ are not infrequently produced in the course of operations for the relief of such troubles.

Occasionally cases of congenital fistula present themselves, but they are rare. The same methods of relief apply to them as to other cases; but at an early age the parts are usually too small to permit of successful operation.

Symptoms.—In cases where the bladder is punctured by an incised wound, the fact is at once made known by an immediate and involuntary escape of urine through the puncture. The same phenomenon indicates the presence of a fistula caused by laceration, due to too rapid delivery, or by ulceration due to pressure of pessary, calculus, or any foreign body in the vagina. This escape of urine may be continuous from the date of its first appearance or may be interrupted. But as the vast majority of fistulæ are due to prolonged and difficult labor, the usual symptoms are those that follow such an experience. The bruised and sloughing tissues are a warning of the more serious condition to follow. But the actual extent of the injury cannot be known till the slough separates and the urine escapes by the fistulous opening thus established. This may occur on the third day, and may be delayed till the third week. From this time on the urine may flow constantly, or may be retained for several hours, dependent upon the position of the patient and the nature and seat of the fistula. If the fistula is high in the septum, the bladder will have retentive power till filled up to that point; and when the patient is in an erect posture there will be no involuntary escape of urine if the bladder is evacuated frequently enough to prevent the overflow. Sometimes a fold of the vagina, the pressure of the uterus, or the approximation of the edges of the fistula, especially in fissure-like openings, may afford retention for hours. In uretero-vaginal fistula, when only one ureter is involved, there may exist the unusual condition of a constant dribbling of urine from the vagina and occasional normal micturition.

Unless the woman devotes almost her entire time and efforts to personal cleanliness, the mucous and cutaneous surfaces over which the urine flows soon become inflamed and excoriated. The vulva, the thighs, and the nates, being kept constantly wet with this irritating excretion, become red, swollen, and abraded. Frequently they are the seat of vesicles and pustules, and even occasionally of deep ulcerations and abscesses. Such abrasions within the vagina soon become coated with a calcareous or phosphatic deposit, causing the greatest suffering.

When there has been an extensive loss of tissue the base of the bladder may become inverted through the opening, suffer the same abrasion, and become coated with the same deposit, rendering it exquisitely sensitive. Otherwise the size of the fistula makes little difference with the discomfort of the patient. Women are as constantly wet when the opening is not larger than a pin's head as when large enough to admit one or two fingers, the small opening, as Dr. Emmet explains, acting like the spigot in a barrel. A disagreeable urinous odor is constantly emitted from her person, which excludes her from society and forbids her participation in the ordinary pleasures and duties of life. Dieffenbach gives a sad picture of many of these unfortunate women of his time, shunned by their friends, disgusted with themselves, and dragging out a most pitiable and miserable existence.

Diagnosis.—When the symptoms above described exist, the probabilities are that a urinary fistula will be discovered. Sometimes, however, a chronic cystitis will result in paralysis of the bladder and constant dribbling of urine from the urethra, producing all the disagreeable symptoms of a fistula. If the fistula is large, a digital examination will readily detect the lesion without the use of speculum and probe; but pinhole openings are sometimes most difficult to discover, while in long-standing cases of extensive lesions, with abrasions and cicatricial bands, the relation of the parts is only discovered by careful and painstaking investigation. When the opening is very minute, the whole field of the vagina must be gone over carefully with tenaculum and probe. The folds of the vagina are smoothed out, the probe gently insinuated into every suspicious fold or fissure.

Should this fail to reveal the fistula, resort can be had to injecting milk into the bladder, or water stained with indigo or carmine. The bladder is slightly distended with the chosen fluid, while the septum is carefully watched for its appearance upon the vaginal wall. Bozeman has devised an ingenious test for cases in which the previous methods are contra-indicated by irritability of the bladder. The test is based upon the fact that urine instantly passes through linen, while secretions of the vagina do not. The suspected location of the fistula is carefully dried with absorbent cotton, a piece of thin linen is spread smoothly upon it, and carefully watched for the point of moisture to appear.

Prognosis.—In artificial fistula, made for the relief of calculus or obstinate cystitis, it is a well-known fact that it is with difficulty that the fistula can be kept open long enough to effect a cure. Not until Dr. Emmet devised his method of "working the button-hole" was this difficulty obviated. In these cases the fistula is a simple slit or fissure, the edges of which fall naturally together when the speculum is removed. We may, therefore, infer that where the lesion consists of a laceration in the vesico-vaginal septum, due to rapid labor or accidental puncture, unless it be so situated that the natural strain of the parts tends to keep the lips of the wound apart, under proper attention to cleanliness and frequent emptying of the bladder, spontaneous recovery may be hoped for. Even when a slough has occurred, spontaneous recovery has taken place in a limited number of cases. In the majority of cases, however, the lesion becomes permanent and requires surgical interference for its relief.

"Prior to the application of the metallic suture by J. Marion Sims and a proper mode of exploration furnished by his speculum, any attempt for the relief of the injuries under consideration was uncertain in result, and the operation regarded as an opprobrium by the profession." To fully appreciate the significance of these words of Dr. Emmet, and the credit due to Sims, it may be interesting and profitable in this connection to look into the history of the treatment of the lesion under consideration.

History.—With Henri de Roonhuysen—a Dutch obstetrician of Amsterdam, 1663—rests the honor of being the first to devise, employ, and describe the operation for relief of vesico-vaginal fistula. The description he gives is so unique and interesting, and so rarely to be found, that I give it in full. This is from a French translation of the original by Herrgott of Strassburg. The operation is done in the following manner: The patient is placed upon her back on a table in a good light; the upper part of the body is covered, the lower part fixed with bands as in the operation for cystotomy. This done, the vagina is dilated by a speculum as large as the circumstances will permit. The vaginal mucous membrane along the border of the tear, where it is in contact with the vesical membrane, must be denuded, but the bladder itself must be touched as little as possible, for by the kindly act of nature the vagina is united by inflammation to the borders of the tear in the bladder in such a way that when only as little a portion as necessary has been detached, it is wont to heal perfectly. This freshening of the edges can be done by means of a little sharp pinch of the scissors or bistouri, or any other instrument the surgeon is in the habit of using. I find it is accomplished quite well by a slight sharp pinch of the scissors, but they ought to be as sharp as possible in order that they may not produce contusion, but freshen a little the edges of the tear to make them red or bleeding, so that they may unite immediately and contract adhesions to each other. The retention need not always be accomplished with gold or silver pins, as is done in harelip, but with pins made from the strong quills of the swan, sharpened and pointed. These are preferable not only by reason of their flexibility, but by the fact that they do not cause compression of the surrounding parts if one takes the precaution to guard them with waxed silk. For when the pins are applied they adapt themselves by virtue of their elasticity.

The parts must then be anointed with a cicatrizing salve (of which he gives the formula), and upon the wound should be placed two or three flat pledgets saturated with oil or warm balsam, and the vagina filled with pieces of sponge saturated with oil, for the purpose of making a little pressure upon the wound and sustain the dressing. All this should be steadied with some compresses and supported by a T-bandage, which should remain in place three or four days. The bandage and compress are removed when the patient wants to urinate, but she ought to do it with caution. The patient should remain constantly in bed, lying upon her back, the hips slightly elevated, till healing is accomplished.

Roonhuysen does not describe cases operated upon by himself, nor does he state how many times he practised it; but a Swiss surgeon, J. Fatio, 1752, records two successes by Roonhuysen's method. Naegele claimed that this procedure of Roonhuysen was simply impossible, basing his objections upon the quill pin, but he nowhere claims to have tried it. Kilian made similar objection to the operation. But Herrgott has experimented with quill sutures in tissue similar to that of the vagina, and finds them entirely practicable. Moreover, the minute and careful description of all the details of the procedure bears evidence in itself of being a genuine account of what had actually been done.

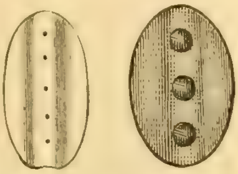
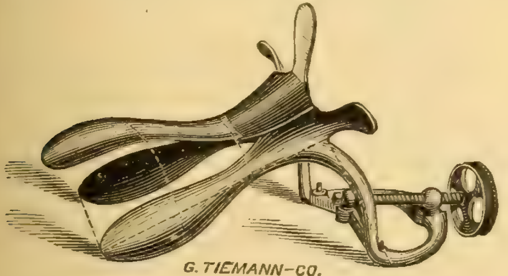


Fig. 5101.—The Lead Button.

In this simple description of Roonhuysen's we find all the principles and methods of treatment necessary to deal successfully with fistulæ. He used the speculum to thoroughly expose the parts, vivified the edges of the fistula with knife or scissors, avoided the bladder membrane in denuding, and fastened the edges with a suture. What have we added to this more than to modify the suture and adjust a self-retaining catheter?

The method, however, was not established, either by him or any of his immediate followers, as a recognized procedure in surgical practice, and was forgotten. No progress in dealing with fistula was made during the eighteenth century, except the use of the catheter, by Vorlten, 1720, and the introduction of silk interrupted sutures. Cauterization of the edges with hot iron and nitrate of silver was used, but with only limited success. In the beginning of this century Naegele, 1809, renewed interest in this lesion and its repair. He devised and employed four methods of operation, but failed to obtain any success. Professor Ehrman, 1826, operated in two cases by simple suture after freshening the edges, and obtained complete success in one after repeated cauterizations.


G. TIEMANN-CO.
Fig. 5102.—The Bozeman Speculum.

Gosset, of London, 1834, reported a successful case operated upon by him, in which he used uninterrupted sutures of silver gilt, or gilded silver wire, fastened by twisting. Jobert de Lamballe, the same year, in France, introduced the method of transplanting tissue from the labia, the buttocks, or thigh, and fastening it to the denuded edges of the fistula. This did not prove satisfactory in its results, and he adopted the interrupted suture with the additional procedure of incising the tissues at certain points in the vagina—cystoplastie par glissement—to relieve tension upon the sutures and allow the edges to rest in contact.

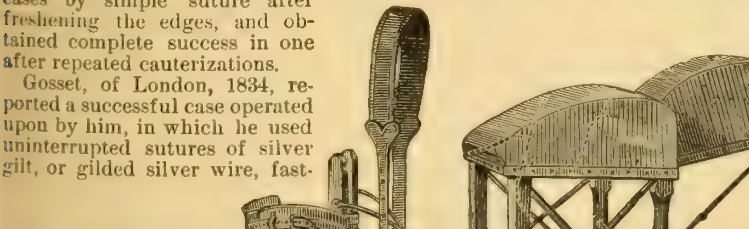
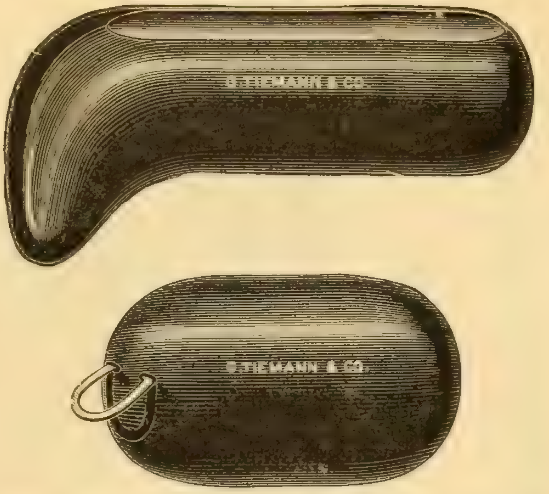


Fig. 5103.—The Bozeman Chair.

Then Dieffenbach, 1845, gave his experience to the profession. He says: "I have operated upon one woman eighteen times without success. I have closed the entire cavities of these unfortunate women gathered from all countries. I have lived in the midst of them, and I have realized only a small number of successes." He claimed to have cured by the suture only one fistula of any considerable size, but a great number of small ones by the actual cautery.


G. TIEMANN & CO.
G. TIEMANN & CO.
Fig. 5104.—The Bozeman Hard-rubber Dilator, Pistol-shape and Oval.

Wurtzen, of Bonn, who after Dieffenbach was for a long time the only one who operated upon fistulæ, failed to cure in one case after thirty-three operations. According to the statistics of Simon, Wurtzen, up to 1842, cured only 4 women out of 18. From 1842 to 1852 he cured 7 out of 17, or 11 successes in 35 cases.

Gustave Simon, 1854, published a critical review of the operation of Jobert in which he presented his own method of operating, and reported six cases in which he had obtained perfect success in four, and partial success in the other two.

In our own country, Hayward, of Boston, was the first to report a cure, May 10, 1839, achieved by him in a case of fistula of fifteen years' standing, which had resisted treatment by cauterization and catheter. He operated with the patient in the lithotomy position, the vagina opened by means of retractors, and the anterior vaginal wall pressed down by a bougie in the bladder. The edges were denuded, the surfaces coaptated by interrupted silk sutures, a catheter fastened into the bladder, and the patient put to bed upon her right side. Upon the sixth day firm adhesion had taken place and the stitches were removed. He says: "I had never seen the operation done till I did it myself, nor could I find any description of the mode which others had adopted that was sufficiently clear and explicit to be of much service." In 1851 he reported a series of 20 operations on 9 different patients, with 3 perfect successes, 4 great relief, 2 no benefit. Of these 5 had 1 operation, 2 had 2, 1 had 5, and 1 had 6.

In 1847 Pancoast, of Philadelphia, reported two cures by a method called the "gusset suture." The peculiar feature of this consisted in splitting one edge of the fistula and paring the other to a wedge shape. The latter was then engaged into the former and held by sutures. The same year, 1847, Mettauer, of Virginia, reported a successful case of fistula treated by him with leaden sutures after freshening the edges. He also used the catheter. So simple seemed the process of cure, and so pronounced his success, that he did not hesitate to declare all fistulæ in the realm of relief.

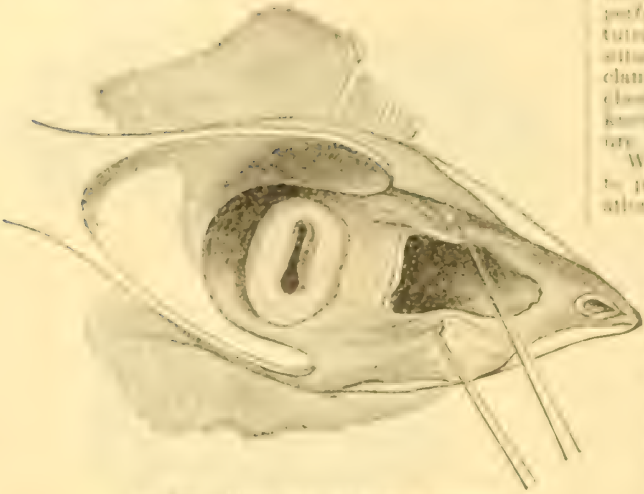


FIG. 5105.—Fistula as shown by Sims' Speculum.

From this brief historical sketch it becomes apparent how perfectly at sea the profession was even as late as the middle of the present century, regarding any well-established procedure, or faith in the successful application of any of the devices used. Here and there, occasionally, an operator met with success, and the achievement was heralded as a great triumph. But no two adopted exactly the same method, and the success was ascribed more to good luck than the proper application of any particular surgical method. It was left for the genius, the careful observation, the untiring energy and enthusiasm of one of our own countrymen, J. Marion Sims, to grasp all the essential principles, to work out to complete success, and give to the profession what is recognized the world over as a thoroughly reliable method of dealing with urinary fistula. The more credit is due him as he worked independently of others and without any adequate knowledge of what had been accomplished by them. Yet, as Dr. Emmet says: "were we to accept that Dr. Sims was as familiar as we are at the present time with what had been accomplished before his day, it should not lessen the credit due to him. What had been done fell on barren soil, its fruit was not appreciated and was destined to be forgotten. From Dr. Sims' hands the operation was accepted by the profession. It was immediately put into successful practice, and to the present day it has not been materially modified, for the better, either in its principles or in the mode of execution." His first article was published in the American Journal of the Medical Sciences, 1852. The essential features of the procedure, as there set forth by him, were, first, a means by which the vagina could be thoroughly exposed and the fistula brought into view, viz., the knee-chest position and the duck-bill speculum; second, a suture which could be left in place long enough to secure healing without exciting inflammation or ulceration, viz., silver wire secured by perforated shot; third, a method of draining the bladder during convalescence—Sims' self-retaining catheter. During the next five years he modified somewhat the details of these procedures and set them forth in an address before the New York Academy of Medicine, 1857, "Silver Sutures in Surgery." In the operation as then described and which he regarded as perfect in all its details, he substituted the simple interrupted silver suture, secured by twisting, for the clamp-suture, and instead of the knee-chest position, employed what is known universally as the Sims posture.

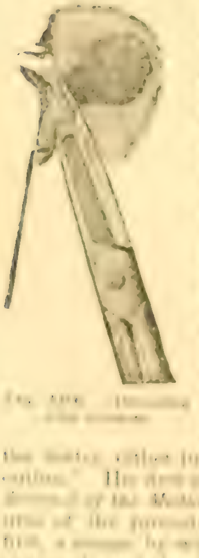


FIG. 5106.—Denuding with Scissors.

While Sims was thus working out to perfection the details of his operation, Gustave Simon, of Darmstadt, Germany, was also employing his mechanical skill and ingenuity in endeavors to relieve the same distressing affliction. The results of his labors, and the details of his operation, were given to the profession in 1862, although he had previously published an article on the subject in 1854. He placed the patient in an exaggerated lithotomy position, exposed the fistula by a duck-bill speculum of his own device, and by means of lateral retractors, vivified the edges with a knife, regardless of encroachments upon the bladder membrane, and used silk sutures in uniting the edges. When much strain was expected, he employed a row of deep sutures far from the edge to hold the parts, and a row of superficial sutures to secure exact approximation of the edges. He allowed his patients to sit up and pass urine naturally when possible. Simon also devised and practised what he called Kolpokleisis, in cases in which the fistula itself could not be closed. This consisted in completely occluding the vagina by denuding a surface on the anterior and posterior wall of the vagina below the fistula, and uniting them by suture. This made a common receptacle for the urine and menstrual blood.

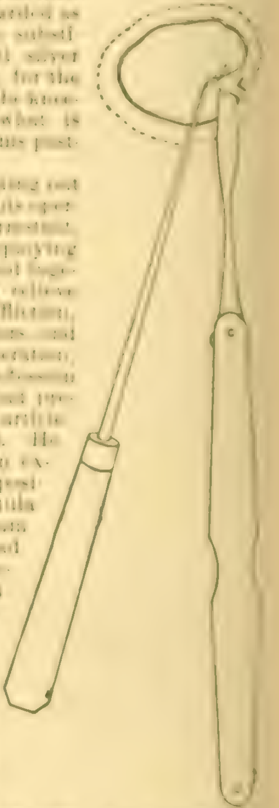


FIG. 5107.—Denuding with Knife.

Intimately associated with the operation for repair of fistula, both in this country and abroad, is the name of Bozeman. He is a strong advocate of long and complete preparatory treatment and the use of the button suture. The latter consists of a disk of sheet lead nicely cut and moulded to fit the tissues in each individual case. This is perforated with a row of holes along the median line, through which the silver sutures are drawn and made fast by perforated shot (Fig. 5101). This, it is claimed, acts like a splint, and so favors healing by preventing motion. It has the disadvantage, however, of concealing the wound, preventing the nice adjustment of the edges and the tightening or loosening of each individual stitch which is afforded by twisting the wire. He employs a peculiar speculum invented by himself and a contrivance for sustaining the patient in the knee-chest posture when under ether (Figs. 5102 and 5103).

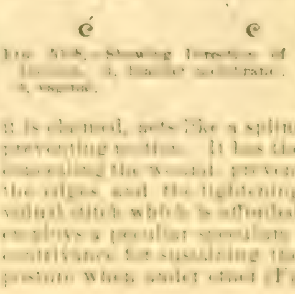


FIG. 5108.—Showing Inversion of Edges. a, Bladder membrane; b, vagina.

His method yields most favorable results in his own hands, but is too complicated for the general practitioner.

Dr. Bozeman is a vigorous opponent of the operation of Kolpokleisis as practised by Simon. He claims that in many cases where this was resorted to by Simon, a sufficiently long and persistent course of preparatory treatment would have enabled the patients to be relieved with entire restoration of bladder and marital functions. Kolpokleisis, even in cases that resist all other efforts at relief, is only a delusion. It may keep the patient dry, and thus afford relief for a short time; but unfortunate consequences always attend the retention of urine in a pouch thus formed when complete drainage is not secured. The urine decomposes, calculi form, and a cystitis may be established that, sooner or later, leads to disease of the kidney, uræmia, and death. Dr. Emmet insists that Kolpokleisis should never be resorted to under any circumstances.

The man that has done the most to popularize operation for fistula in this country, while claiming no originality in the matter, is Dr. Emmet.

Frequency of Fistula.—No statistics can be given, showing the frequency of this accident. There is no hesitancy in saying that it is a rare condition, and, if the experience of New York gynecologists is an index of experience throughout the country and the world, it is becoming more and more infrequent. The Woman's Hospital, in New York City, was established primarily for the express purpose of relieving fistulæ, and its early history bears record of few cases of a different nature. During the first five or six years of its existence it was customary to have two or three operations each week for relief of fistulæ. At the present time scarcely that number can be seen there in a year.

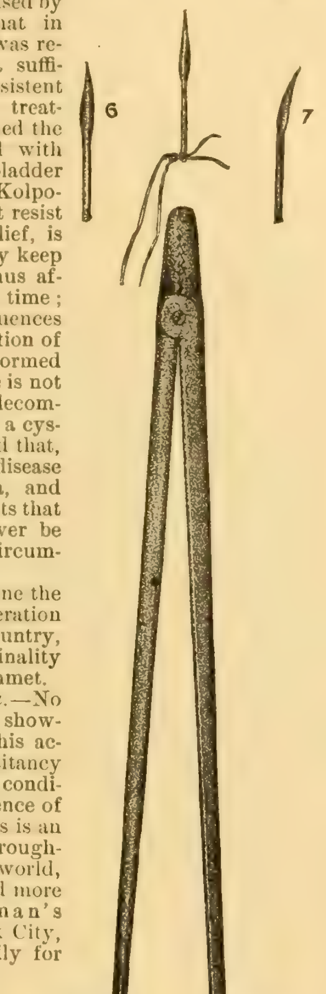


Fig. 5109.—Needles and Needle-holder.

This change is due to two causes: First, the operation has become so popularized that when such accident does occur, the local physician repairs the injury; second, the prompt application of forceps in cases of difficult labor prevents its occurrence. Whatever abuses and injuries may attend the too frequent and too early use of forceps in parturition, all authorities are now agreed that their timely use is most efficient in preventing fistulæ. "Authors are disposed to attribute the accident of vesico-vaginal fistula in many cases to the awkward use of obstetric forceps; but from careful analysis of these cases, and my own experience, I am well satisfied that for one case thus produced their judicious application has prevented it fifty times" (Sims). "I do not hesitate to state that I have never met with a case of vesico-vaginal fistula which, without doubt, could be shown to have resulted from instrumental delivery" (Emmet).

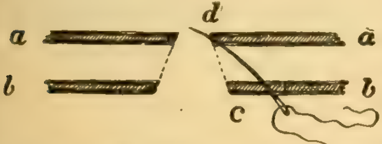


Fig. 5110.—Direction of Needle. *a d*, Bladder membrane; *c b*, vagina.

Treatment.—Methods of Cure. Spontaneous Cure. Small fistulæ will frequently close without any interference, through the process of healing and granulation. The smaller the fistula the greater the probability of such an occurrence. This process of nature can be encouraged and hastened by proper attention to cleanliness. The constant drainage of the bladder, too, by self-retaining catheter, assists greatly this spontaneous cure. Any procedure that maintains a constant healthy, granulating process along the edge of the fistula tends to recovery. Corradi cites a case of his, recorded by Jenks, which for a year had resisted all methods of treatment, even Sims' operation. He thereupon had a gold button with double facets made to fit the fistula. The button was inserted so that one facet was in the bladder, the other in the vagina. Micturition was immediately established, and not a single drop of urine passed any longer by the vagina. For five years the woman wore this button without experiencing any inconvenience. Then by accident the button dropped out, and the urine continued to pass entirely by the urethra. A few days afterward Corradi examined the patient, but found no fistula. In this case the stimulus of the button had encouraged granulation till it had reached up over the head of the facet that was in the bladder, while the button was sloughing out below.

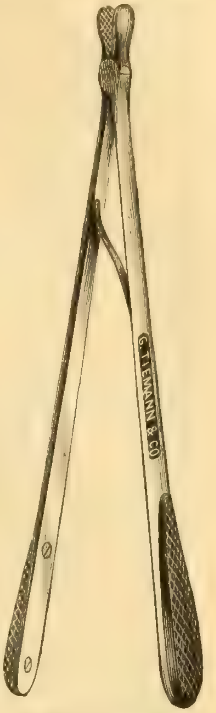


Fig. 5111.—Emmet's Needle-holder.

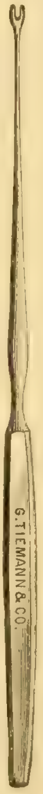


Fig. 5112.—Sims' Fork.

Caustics.—For many years caustics were the chief reliance in the cure of fistulæ. As late as 1839, Dupuytren declared that sutures were of no avail against the injurious influence of the urine on the wound, and nothing but the actual cautery was sufficient to excite the necessary degree of action in the edges of the fistula to produce a full granulation. All the caustic acids, caustic potash, nitrate of silver, and the actual cautery were employed. In cases of extremely small fistulæ the cautery will frequently effect a cure. Nitrate of silver is the best application. It is also frequently resorted to with success to complete the cure after suture, when an opening has been left in the angle, or points along the line of union have failed to unite. In such cases frequent application should be made and continued till strong, healthy granulation has been produced. After that cauterize less frequently; allow the granulations to accomplish what they can before burning them again.

Preparatory Treatment.—It is important that the general health of the patient should be in as good condition as may be. But one need not wait too long for this. The local condition of the parts is still more important. Before operating, the edges of the fistula and surrounding parts must be put into as healthy condition as it is possible to get them. Sitz-baths, hot-water douches, and the most scrupulous methods of personal cleanliness should be employed. All incrustations of urinary salts, wherever found, are to be gently removed by streams of warm water, a cotton swab, or picked off with the dressing forceps. The excoriated surface beneath is then brushed over with a solution of nitrate of silver. This must be persisted in two or three times a week, and in the meantime the parts kept thoroughly protected from the urine by an ointment. The most efficient ointment for this purpose is that given by Bartholow, under the head of "Hebra's Ointment": "Take of benzoic acid, finely levigated, one part; white wax, one part; paraffin, two parts; almond oil, two parts. Melt the wax and paraffin by heating with the oil, and stir the mixture briskly, along with the benzoic acid powder, in a warm mortar, until the mixture thickens." When required for use, a certain amount of it should be rubbed up with a little vaseline or glycerine. It should be used quite stiff, so that it may form a coating over the inflamed and delicate surfaces. With careful attention to cleanliness, and constant use of this ointment, I have kept patients with artificial fistulæ entirely free from all excoriations or irritation.

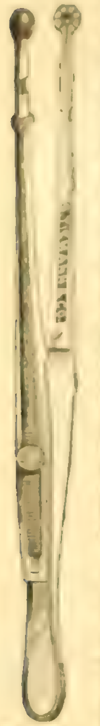


Fig. 5113.—[illegible]

All cicatricial bands stretching across the vagina, obstructing the view, narrowing the canal, or distorting the relations of the parts, must be thoroughly obliterated. This is accomplished by nicking or cutting them here and there along their course, and causing their absorption by pressure. When these constricting bands exist across the posterior wall, reaching up onto the sides of the vagina, they can be put upon the stretch by placing one or two fingers in the rectum and the thumb in the vagina. Then with a pair of blunt scissors in the right hand each band is snipped or cut superficially at several places, and the pressure of the thumb increased to tear the tissue still deeper. This avoids the hemorrhage that would be produced by the deep incisions of a knife. When the bands cannot be reached in this way, a speculum must be inserted and pressure made here and there with a depressor to bring the bands into view,—when the same process of snipping is repeated. To keep these bands on the stretch and stimulate absorption by pressure, a "Sims glass plug," or "Bozeman dilator" (Fig. 5114) is immediately inserted, and held in place by a layer of cotton and a T-bandage.

This plug or dilator can be procured of any size, and must be adapted to each individual case. It should be large enough to distend well the parts. Its presence occasions some distress, which may be relieved by anodynes. During the healing process the patient is kept in bed, and the plug held as constantly in place as the circumstances will permit. It should be removed at stated intervals to permit of antiseptic douches, and well smeared with carbolized vaseline before being reintroduced. At the expiration of ten days or two weeks, if the parts are not sufficiently pliable and the vagina roomy enough to permit the easy performance of the operation, the process is to be repeated.

If cicatricial bands do not exist, but the canal is narrowed through loss of tissue, and the edges of the fistula so drawn apart that they cannot be brought into apposition, longitudinal incisions, three or four in number, parallel to the long diameter of the fistula, should be made through the membrane of the vagina with a knife, and the dilator or plug inserted as described above. Sometimes this becomes a very painful and tedious process, but is absolutely essential to success.

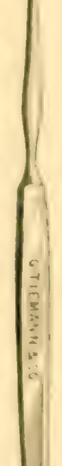


Fig. 5114.—[illegible]

Sims' Operation.—The patient, properly dressed and protected by covering, is placed in Sims' posture. It is well to have two nurses and two assistants. One nurse holds the speculum and elevates the buttock; the other attends to the sponges. One assistant administers ether; one assists in the operation and does the sponging. The instruments required are: Sims' speculum, long-handled left and right curved scissors (Emmet's curved scissors are usually sufficient), a long-handled knife with narrow blade, two or three tenacula, needles and needle holder, counter-pressure hook and fork, twisted silk for carrying thread, No. 27 or 28 silver wire, twisting forceps, wire shield, sponge holders and sponges (see accompanying cuts).

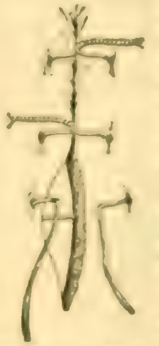


Fig. 5115.—Adjusting the wire.

The steps in the operation can be comprised under three heads: First, denuding or vivifying the edges of the fistula; second, introducing the sutures; third, adjusting the edges and fastening the sutures.

Denuding.—The line of union should be as nearly as possible in the long axis of the vagina; but more important still is it that the margins be drawn together in the line of least traction or resistance. The margin of the fistula is caught with a tenaculum at any selected point, and a strip of tissue removed with the scissors or knife.

It is a good plan to make this strip of tissue encircle the entire fistula without cutting or breaking it. Then you are sure of obtaining a perfectly clean surface. When the vesical mucous membrane is included in this denudation, there is apt to be troublesome hemorrhage. Sims therefore advised that this be carefully avoided; the incision taking the direction of the dotted lines as in Fig. 5108, *a* being the vesical membrane and *b* the vaginal. If the removal of one strip gives sufficiently wide surface to afford firm union, the wound is ready for the sutures.

Ordinarily, however, it is necessary to take off a second or third strip outside this, on the mucous membrane of the vagina, to get as broad a surface of union as may be.

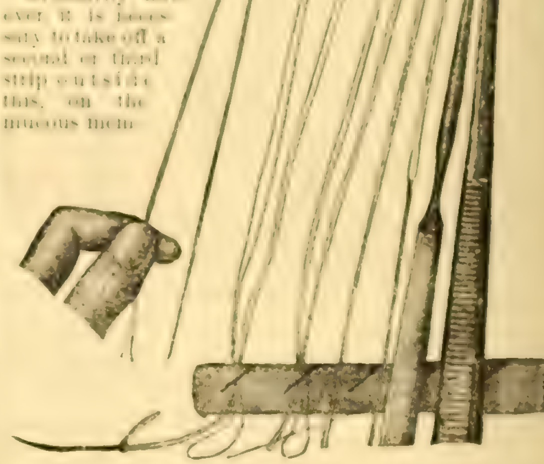


Fig. 5116.—Twisting the Wires. (Savage.)

At each end of the fistula the denudation must be made to terminate in an acute angle by extending the denudation out to a point on the vaginal membrane. This avoids all puckering of tissues when the sutures are tightened, and thus prevents the little orifices that otherwise are apt to result at either end of the line of union. Should any troublesome hæmorrhage occur, it can usually be controlled by hot sponges, torsion, pressure, or ligature. To exert pressure, Dr. Emmet recommends pushing the centre of a handkerchief, or any thin cloth, through the fistula, then packing cotton into the sac thus formed in the bladder till the mass is too large to be drawn through the opening. Now, by pulling on the corners of the handkerchief, any degree of pressure can be made. Another device of Dr. Emmet is to pass a suture from the vagina through the septum into the bladder, at some distance from the margin of the fistula, and out into the vagina again, thus surrounding the offending vessel, and ligating it temporarily in the tissues.

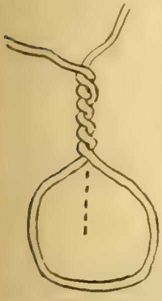


Fig. 5117.—Stitch before Shouldering. (Mundé.)

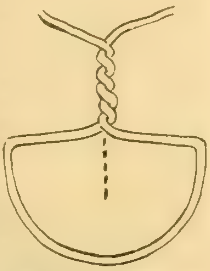


Fig. 5118.—Stitch after being Shouldered. (Mundé.)

Care must be taken in doing this to avoid ligating a ureter. If the mouth of the bleeding vessel can be caught, there is no positive objection to ligating with fine silk or catgut; but any foreign body between the lips of the wound is to be avoided if possible.

Introducing the Sutures.—The needle may be either straight or slightly curved, and from one-half to one inch in length. It is armed with a double carrying thread of fine silk about six inches long, into which the silver wire of the same length is hooked and made fast. The wire should be sharply bent over the thread and passed at that point with forceps, to make as slight a resisting point as possible in passing through the tissues.

It is well to begin suturing at the most distant angle of the fistula. Here the tissue is caught up with a tenaculum and the needle inserted at about one-fourth of an inch from the margin of the denudation, and directed through the tissues so that it will come out just at the edge of the bladder mucous membrane.

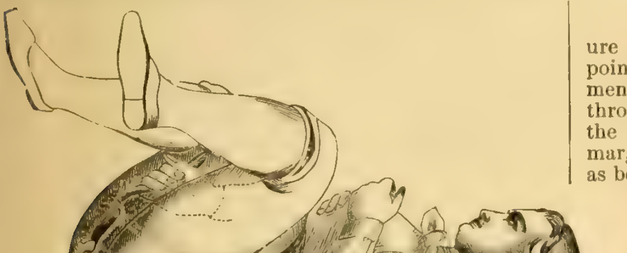


Fig. 5119.—Patient in Position. (Simon.)

Puncturing the vesical membrane causes hæmorrhage at the time, and may result in a permanent leak hole. As soon as the point at which the needle is to emerge is determined, counter-pressure is made just beyond with the blunt or counter-pressure hook. This facilitates the passage of the needle, and prevents straining of the tissues. The needle is thus pushed through as far as the grip of the needle-holder will allow. Then it is caught at the point and drawn through while the counter-pressure is still applied. The needle is then inserted at the point corresponding to its exit on the edge of the bladder membrane, on the opposite side of the fistula, and directed through the tissues till it makes its appearance through the vaginal membrane one-fourth of an inch from the margin of the fistula. The counter-pressure is applied as before. The needle, with carrying thread and silver wire, is now drawn through till the ends of the wire can be grasped on both sides. If the tissues are delicate and there is danger of tearing them, it is well to support the thread as it is drawn through with a Sims fork. But the wire must not be drawn into the tissues till the needle has been passed through both sides, and then it is to be slid through both sides at the same time. Otherwise it gets badly kinked. The ends of the wire are twisted together one or two turns, and held out of the way by the assistant. In this way the stitches are passed one after the other from one-fourth to three-eighths of an inch apart, and as evenly in all respects as it is possible to get them.

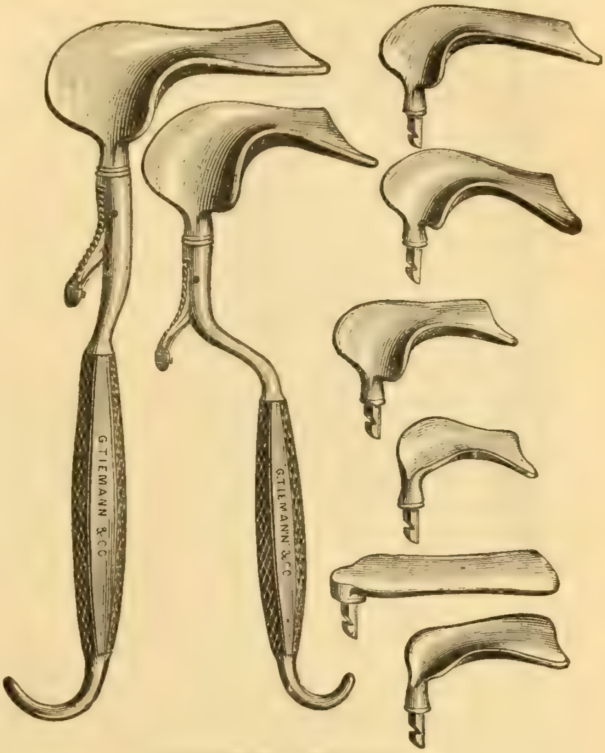


Fig. 5120.—Simon's Speculum.

Securing the Stitches.—Commencing again at the remoter angle of the fistula, both ends of the first wire are grasped firmly, two or three inches from the tissues, with the twisting-tongs, and sufficient tension made to draw the suture taut. With slight pressure of the tenaculum the wire of either side is now bent, near the tissues, at a sharp angle, till it meets the wire of the opposite side directly over the line of union that is to be formed. The shield is slid down the wire and firmly pressed against the tissue, while sufficient strain is put upon the wire, by pulling, to bring the edges of the wound into firm apposition. While this tension is still maintained, the wire is bent over the shield and twisted down to the tissue. The shield is now removed to see whether this suture holds the edges in close and even apposition. If not, the shield is reapplied and one or two more twists are given to the wire. Or if too tight and strangulation or cutting of the tissues threatens, the tension can be relaxed by giving the wire one or two turns in the opposite direction. And in this lies the advantage of securing silver wire by twisting rather than by clamp, button, or shot.

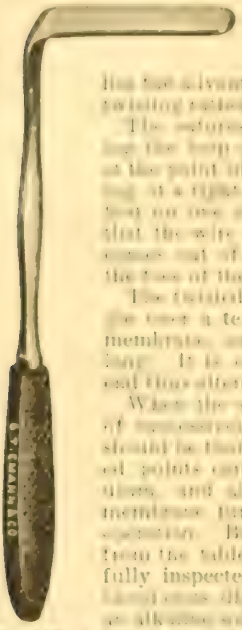


FIG. 5121.—Simon's Retractor.

The sutures are now shouldered by catching the loop of the stitch with a tenaculum at the point of exit from the tissue, and pulling at a right angle to the line of the fistula, first on one side and then on the other, so that the wire is bent at a right angle when it comes out of the tissue and lies flat across the face of the wound.

The twisted end is now bent at a right angle over a tenaculum, flat upon the vaginal membrane, and cut off about half an inch long. It is customary to turn the twisted end thus alternately one side and the other.

When the sutures have all been disposed of successively in this manner, the wound should be thoroughly inspected and all everted points carefully tucked in with a tenaculum, and all inverted points of mucous membrane turned out. This completes the operation. But before the patient is removed from the table the bladder should be carefully inspected by passing a catheter. Any blood-clots discovered must be dissolved by an alkaline solution and washed out; any active hæmorrhage controlled by hot water or ice-water injections.

The self-retaining catheter is now placed in position, and the patient put to bed with a narrow dish between her thighs to catch the urine. The catheter should be removed and thoroughly cleansed every night and morning, and a vaginal douche administered at least once a day. The bowels may be kept constipated till after the fifth day, or an evacuation obtained daily by Hunyadi water or other laxative. It was Dr. Sims' custom to keep the bowels quiet. The patient is kept upon her back, and pain is relieved by opium or morphine. The sutures may be removed upon the eighth, tenth, or twelfth day, according to the relative vitality of the patient, and the healing qualities of the tissues.

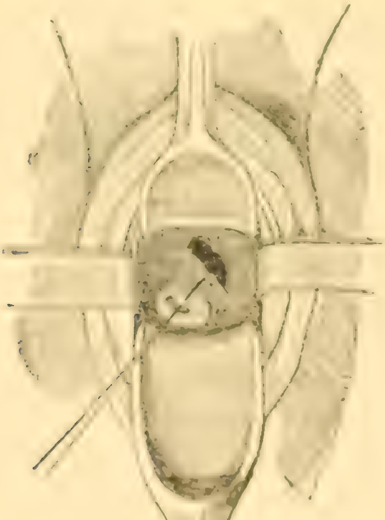


FIG. 5122.—Fistula as shown by Simon's Speculum.

Care must be exercised not to pull the wound apart in removing the sutures. Catch the twisted end with the twisting-tongs and straighten it up gently at a right angle with the surface. In doing this the loop of the suture will rotate in the tissues and bring a bright point of it into view, when it can be easily snipped off with scissors. The view is facilitated by making slight pressure on the tissues with the points of the scissors at the point of exit of suture. In drawing the suture out, force should be directed in such a way that the tissues are constantly pressed toward the line of union, and not dragged away from it.

Some cases require several operations to effect a cure, but slight points of non-union, either at the angles or along the line, may be made to heal by touching them frequently with the stick of nitrate of silver and by keeping the catheter in the bladder.

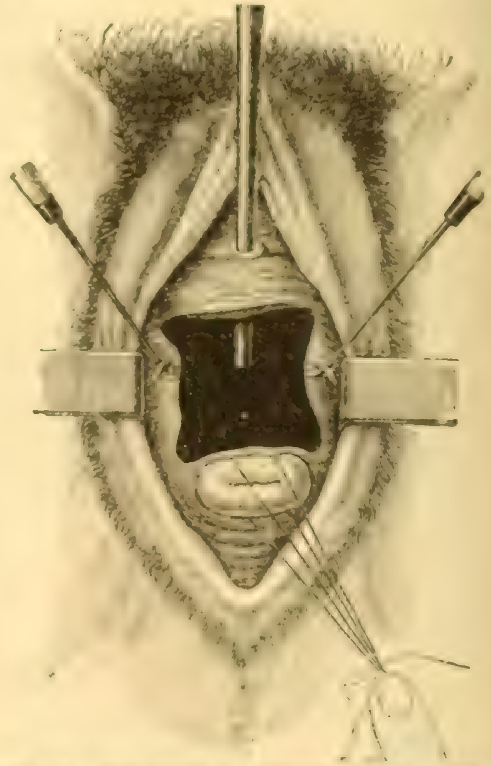


FIG. 5123.—Fistula shown with Retractors and Staff. (Simon.)

Simon's Operation.—It will not be necessary to describe so minutely Simon's operation, but simply to speak of the main points in which it differs from the Sims operation, and illustrate them by the accompanying cuts. Simon worked along the same lines of procedure that Roonhuysen described, and not only attained great success in his operations, but caused it to be adopted among his German confrères as the standard operation. The characteristic features of Simon's operation are these: First, he employs an exaggerated lithotomy position (patient on back, hips elevated). Second, instead of avoiding the vesical membrane, he intentionally incises it if the edges contain much cicatricial tissue. Third, he repudiates the superiority of silver wire, and uses silk. Fourth, he employs no stationary catheter, and allows the patient to void her urine if possible. Fifth, the bowels are kept in a relaxed state to avoid straining, diet is not restricted, and patient is not necessarily confined to bed.

Position of the Patient.—The breech-back (Steiss-Rückenlage) position is attained by elevating the hips and flexing the legs over the belly, so that the breech becomes the most projecting part. If the fistula is situated high in the vagina, the hips must be well elevated, and the thighs flexed as much as possible. The lower the fistula is situated in the vagina, the less the degree of elevation and flexure necessary. Whenever it is possible to expose the fistula well by traction upon the cervix, either by forceps or threads passed through, the speculum is dispensed with, and only side retractors are used, with a staff through the urethra to steady the parts. When this is not practicable he uses specula devised by himself. These consist of an anterior and posterior speculum, and two side retractors (Fig. 5120).

Vivifying the Edges.—The Simon method carries the incision deep enough to extirpate all cicatricial tissue, making a funnel-shaped excavation, and includes all the tissues down through the vesical mucous membrane. Simon prefers the knife.

Sutures.—When the fistula is small a single line of silk sutures is used. In the larger fistulæ every second or third stitch is made a sustaining suture, and is passed at considerable distance from the edge, thus including enough tissue to support the line of union and take the strain off the more superficial (uniting) sutures. This he called his double line of sutures. It is of very little importance whether the suture goes through the vesical membrane or not. But care must be taken to prevent the membrane being inverted and caught between the edges of the wound.

After-treatment.—The patient takes any position in bed that she desires. She passes urine normally whenever she feels the desire, either lying upon a bedpan, sitting up, or getting on the hands and knees. If urination is impossible without too much straining, the catheter is passed at proper intervals. A daily vaginal douche is given, and the bowels are kept open. Vesical tenesmus is relieved by sedatives. Silk sutures cannot be left as long in place as silver wire. They should be removed from the sixth to the eighth day.

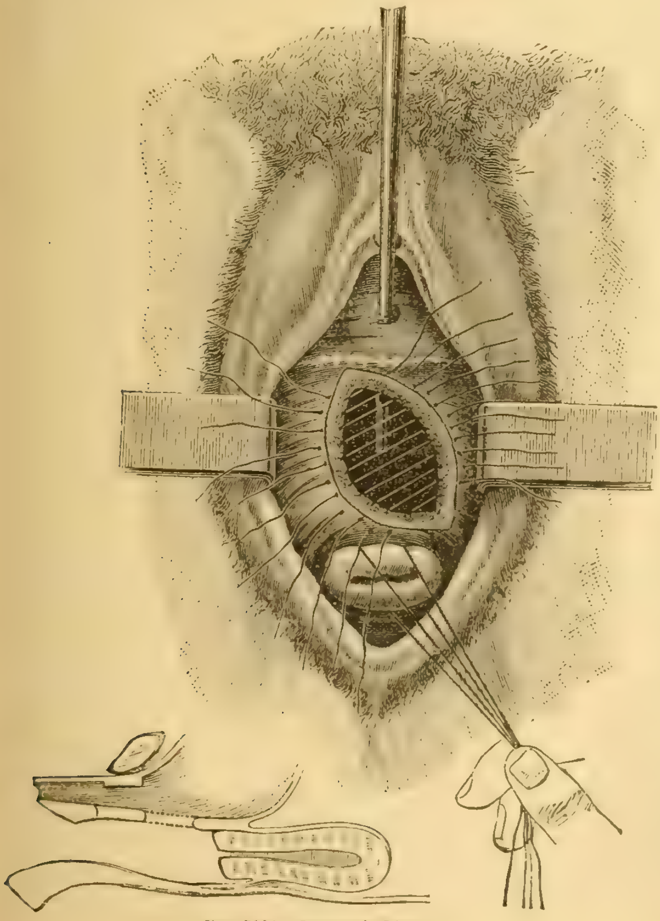


FIG. 5124.—Sutures in Place.

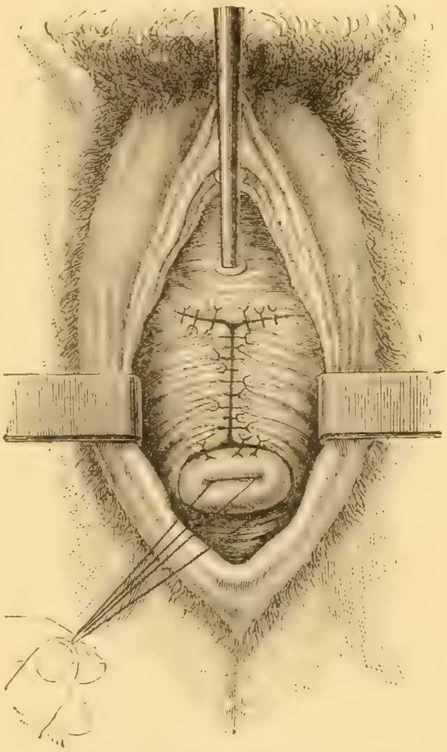


FIG. 5125. Lines of Sutures to close Fistula shown in Fig. 5124.

General Remarks.—The principles and methods established by these great teachers, Sims and Simon, can be followed successfully in all cases. Succeeding operators have modified many details, or combined into a successful procedure some of the features of each. Each operator follows his own fancy in regard to the needle or needle-holder which he shall use, and the material of which his ligatures shall be made. Chinese silk, silver wire, iron wire, silkworm gut, and chromicized catgut are used indifferently; but in large fistulæ, and those so situated that they cannot be reached easily to fasten the ligatures, silver wire is preferable.

There is no department of plastic surgery which gives so great scope for the ingenuity of the operator as that of fistulæ. Each case is a problem *per se*, and demands its own special and individual treatment. No case should be undertaken without careful study of all the factors that are involved in its successful treatment. Where one or more fistulæ exist near the neck of the bladder, there is apt to be stricture of the urethra, which must be relieved before any attempt is made to close the fistula.

In cases that involve loss of tissue at the lower portion of the vagina, extending to one or both rami, there may not be enough tissue between the fistula and bone for the passage of the sutures. In such cases the tissue can be dissected up from the bone to a sufficient extent to give holding ground for the sutures, or a flap may be dissected off the vagina above and brought around to cover the opening. Jobert was the most skilful operator in the use of flaps, which he procured from other portions of the vagina, from the labia, or even the buttocks and thighs.

In vesico-utero-vaginal fistulæ, where it is possible, only the anterior lip of the cervix uteri should be utilized to close the opening;

but in some cases it is found necessary to stitch the posterior lip to the anterior border of the fistula, thus turning the os uteri into the bladder. Menstruation then occurs through the bladder, and conception, as a rule, becomes impossible.

In uretero-vaginal fistula, Dr. Emmet boldly slits up the ureter till he reaches the fistulous opening, thus, as he phrases, reproducing the original lesion. The fistulous tract is then freshened and the entire wound closed by sutures as in trachelorrhaphy. Uretero-vaginal fistulæ are perhaps the most difficult to deal with. Landau recommends excising several pieces from the vesical and vaginal wall, thus producing a vesico-vaginal fistula into the upper angle of which the ureter opens. Then the fistula is to be closed by sutures which, at the upper angle, shall only include the vaginal membrane. If the urine is successful in forcing its way into the bladder in spite of the partial constriction of the ureter which may occur from the stitches, it will continue to do so. There is no danger of occlusion by granulation, for the flow through the ureter is constant. Another device for securing a pervious condition of the ureter is to pass an elastic catheter from the vagina into the ureter, and pass the lower end out through the bladder and urethra. The uncovered portion of the catheter, as now seen through the vagina, is to be covered with the vaginal mucous membrane and the lower urethral wall.

Occasionally a case presents herself where there has been such extensive loss of tissue that all hope of closing the fistula is in vain. The question of closing the vagina (colpokleisis) then arises.

This is to be adopted with great hesitation. Indeed, in this country the experience of the best operators is opposed to it. Continence of urine may be obtained, but, as has been previously expressed, it is only at the risk of constant vesical tenesmus, calculus, chronic cystitis, and all its train of direful consequences. When the base of the bladder, filled with intestines, becomes inverted and protrudes at the vulva, Emmet recommends that enough of the sides of the vagina be united, as in colporrhaphy, to give needed support, but that an opening be left at the most dependent point to allow of free drainage. By proper attention to cleanliness and the use of rubber urinals for females, which can now be procured at the instrument-makers, the patient can be made very comfortable.

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James R. Goffe.

VISION, BINOCULAR. Our eyes are surveying instruments, useful to us because they enable us to determine rapidly and with considerable accuracy the position of other bodies in space. The determination of position and space relations is the province of geometry. By the aid of polar co-ordinates we are able to describe and define the position of any point or series of points; and in this way we can describe the work done by the eyes. It happens also that in this way we can best show that part of the work which is done satisfactorily by one instrument alone, as distinguished from that part which is more accurately, more rapidly, and more vividly done by two used in conjunction.

The position of any point in space is known if its distance and direction from another given point is known. Thus in Fig. 5160, if we take O as the origin from which to measure distances and the line O A as the "base line" from which to estimate direction, only two things are necessary to determine the position of any point, as P, for instance, the length of the line ρ and the size of the angle θ. Now, as we stand at the point O with two eyes at our service, we shall find that one of them is capable of giving us very precise knowledge of the size of the angle θ, but two are much better than one in enabling us to correctly estimate the length of the line ρ. In other words, one eye alone gives us direction, while two together give us distance. If this distinction were absolutely and unreservedly true, a person with only one eye would see everything somewhat as on a painted wall, at whatever distance he happened to imagine it, and the visible world would be of two dimensions, while two eyes would give the added quality of depth, and so recognize solidity. On this account we speak of binocular vision as stereoscopic vision. But it is not true that we are entirely unable to appreciate depth by the use of one eye alone. It is only true, as above stated, that we can appreciate the solidity of space more easily and more quickly for having two eyes, and it seems not only proper but necessary to include in the consideration of binocular vision all those functions that are carried on more advantageously by the aid of two eyes than would be possible with one. Narrower limitations would rob the subject of a great deal of the interest that attaches thereto. It would, indeed, be hard to define the function of a pair of eyes as distinguished in any complete and absolute way from that of one, and it is somewhat doubtful if the sensations experienced by the joint action of both differ, except in intensity, from those which are due to one alone. Hence it is necessary for us to recognize the fact that there is in nature if not in name such a thing as uniocular stereoscopic vision, and to examine carefully the methods by which, through the sense of sight, we obtain our knowledge of space relationships, whether that knowledge comes to us through the instrumentality of one eye or of two in combination. First, it is necessary for us to obtain a clear idea of what is meant by the word *projection*, as it is used in explanation of the act of seeing. This word projection has a technical signification, but as often used it covers a multitude of indefinite ideas, and is supposed to carry a load of explanations for which it is entirely inadequate. Our chief difficulty comes to us at the start, and it is in not being able to understand how an irritation produced by any cause whatever acting on the retina, which is a part of our body, should give rise to phenomena which do not seem to us to have any existence in ourselves, but to be situated apart from us in space. And this impression that the thing seen is entirely separated from ourselves, and connected with us in no perceptible way, is something so immediate and obtrusive that we are not conscious of thinking of it as the result of an intellectual process. Neither are we satisfied with the simple assertion that the mind projects the retinal image outward into space. The statement is probably correct, because the word projection, used here in a technical sense, "means just what we mean it to mean," but as an explanation it needs explain-

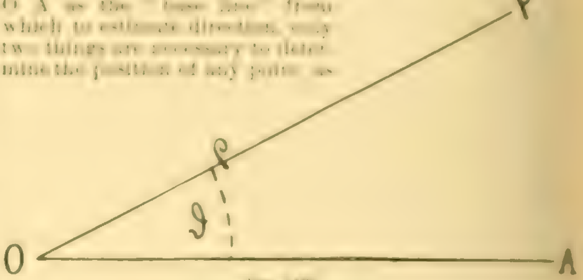


FIG. 5160.

ing. It does challenge attention, this apparent inversion of the common order of events by which a sensation, seeming to have existence in space, is traced by the aid of philosophy to a disturbance of our sensory apparatus; whereas the general rule is that an impression made on our sensory apparatus can only be followed out into space by the aid of philosophy.

This faculty of projection cannot be wholly explained, but it can be classified and shown to be exactly the same mental process by which we locate the disturbances of other sensory nerves, as of touch, or taste, or hearing. When we consider the fact that many of the explanations that we deem satisfactory are merely classifications, we must willingly accept this for the time being, and wait for more gratifying results until we have bridged the gap that separates mental from material processes.

If one wishes thoroughly to understand a machine, let him go to work and make one for himself, or at least try to do so. We cannot make an eye, but we can plan one, and our knowledge of the processes of selection and development will guide us in the choice of material and methods, and after we have finished this imaginary instrument we may hope to have a definite idea of what it will do, and how it does it.

First, however, a word or two regarding our conceptions of space, and our ability to locate disturbances which take place in our general sensory apparatus. It is highly probable that our ideas of space are acquired from experimental realization of the amount of force that is required to move us or our organs from one place to another in response to our volition. Our body occupies space because one part of it refuses to let another part of it pass through, and our idea of its shape is gained from the amount of force which is required to move one part of it until it is stopped by another part, and until we experience the sensation that accompanies the change of state that is produced by these exhibitions of force. Now, our ability to locate a sensation in the end of our little finger when that finger is pressed upon, means that we have a practical knowledge of the amount of force and time necessary to move some other finger until it interferes with the sensation that is going on there, and the concomitant knowledge that the product of the force and time necessary to alter the sensation in the finger pressed upon, by volition directed toward its movement, is practically nothing. We do not mean that we, as highly intelligent beings, have tried these experiments and tabulated the results in our memory, and that we refer to them now whenever we are conscious of a localized sensation. But we mean that we have the knowledge thus gained, and can use it accurately. We may not have gathered it all in by our own personal efforts, but may have inherited it from our remote ancestors, who acquired it gradually while ignorantly resisting the processes of selection. But that we have it, and that it was learned by experience, we do not doubt, and it matters not whether it was our own experience or that of someone else who left to us the results.

Now, after a word or two in regard to the habits of mind by which knowledge is acquired and utilized, we shall be ready to go on in the construction and development of our home-made and artificial eye in such a way that we can see how the habit of projection was acquired, and why we see a thing where it is instead of feeling it upside down on the retina; and, last of all, we hope to obtain an appreciation of what we owe more especially to the binocular arrangement.

There are certain cells in the brain that are devoted to reason and the conscious processes of thought and action. They constitute a kind of "superior court," in which difficult and unprecedented situations are considered and acted upon. There are certain other cells or collections of brain-tissue that receive all messages from the periphery, and transfer them to that part presided over by consciousness, from which, in turn, they receive orders and execute them according to directions. This second class of cells seem to have a certain independent ability to act of its own accord, and to take an independent part in the management of the animal economy; but it acts only by precedent, as a court of common law, and when messages of exactly the same import have been received a certain number of times, the answering appreciation of their significance takes place in a mechanical way, and the necessary orders for action are given even before there has been time for the transmission of this intelligence to the cells where the highest processes of thought go on. Besides all this, that part of the brain first mentioned, after a certain time and a certain amount of experience, absolutely refuses to take cognizance of this routine work. At first it merely recognizes the action that has taken place, and then forgets, and after a while it is absolutely unconscious of the whole routine, accepts the results as reliable, and pays no attention to the detail by which they were collected.

This may not be the most modern and elegant way of stating the laws of mental physiology, but it is near enough the truth for our present purposes, and must be remembered while we watch the development of the eye as an organ specially adapted for the reception of impressions which we find so useful in giving us knowledge of what is taking place in that part of space which is removed from immediate contact with the material of which we are made. In consideration of these facts the localization of a sensation in space is no more to be wondered at than its localization on some part of our body. The fact that we feel at the end of our finger means that the sensation which is there located has come to us so often that the reasoning process necessary to discover the cause and its situation has taken place so many times that it has become a mere matter of routine, and has so dropped from consciousness. The precedents have been so well established by uniformly unvarying results that the matter is decided by the class of brain-cells that act only by precedent. The causes that produce sensations in the finger are multiple. We can trace them to their source, but the sensation itself gives us absolutely no means of measuring distance with anything at all approaching to accuracy beyond the finger itself. The finger is at the end of the beaten track, beyond which it is a matter of exploration for every separate sensation. There seems to be no reason to doubt that, if slight variations in digital sensation were always caused by slight variations in the distance from the finger at which the disturbing element was situated, and if the distance and direction varied with the sensation so constantly that we could put absolute dependence on their significance, we should locate them just as we do visual impressions. There seems to be some slight approach to such location when the point of one's pen scratches over a rough surface in the paper, or when one is walking on soft snow which collects on the sole. Why should this not be the case? We do not think with our arm. We are not conscious with it. It is nothing but a prehensile apparatus having a telegraph system in it, and, as far as consciousness is concerned, it is as decidedly removed from us as the end of our fishing-pole. Sensations from the skin are not actually felt there; they are carried to the brain before we know anything about them, and we can measure the time that it takes them to go. Neither have we any reason to think that the sensation is sent back from the brain to the end of the finger; but, as we said before, it is located there because that is the end of the beaten track over which our mental search for a cause always leads us, and not because a nerve runs out toward it. The nerve has a different function, namely, that of carrying the sensation to the brain and the motive impulse back. If other sensations are as unvarying in their significance regarding some other points farther removed from us in space, the beaten track is extended and the sensations correctly interpreted, in accordance with the same laws which have formerly put it on the end of our finger, or at any other place to which it has been referred.

Perhaps this will seem to be a bold conception to one who has never thought of it before, but it is not without parallel in the every-day experience of all. Space does not permit of any illustrations, except such as are given in passing in reference to the eye itself.

It is generally conceded that the organs of special sense have been gradually and slowly developed from the general sensory organ situated in the skin. Let us take a small portion of the skin surface and without trying to follow closely the actual processes that have gone on through past ages, we will see how much can be done, within the limits of probable variation, toward making it into an organ that will delicately appreciate differences in sensation that are connected in an unvarying manner with differences in direction and distance of the originating disturbance. And we will do this with the full expectation that the mind will locate the sensations caused by these disturbances as far away from the central organ as it can go without leaving the beaten track which it has always and invariably been obliged to follow in its search for a cause.

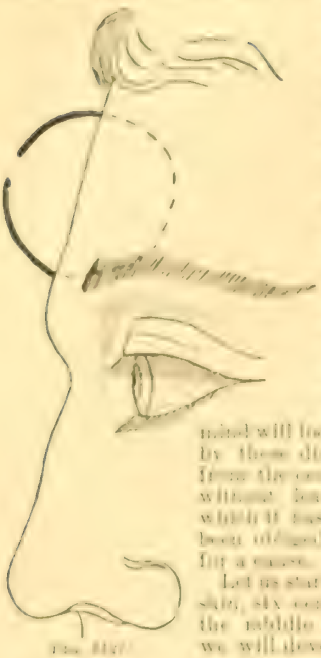


Fig. 5127.

Let us start with a circular patch of skin, six centimetres in diameter on the middle of the forehead, which we will devote to the estimation of the direction and distance of objects that can affect it only through some intermediate substance. In order that it may be devoted especially and exclusively to this work, we will suppose it to be covered over by an inverted vessel about the shape of a teacup, which has a hole in the bottom about one centimetre across (Fig. 5127). There are various influences that can reach this sensory surface through the opening that has been left in the artificial covering, viz., grains of sand however put in motion, drops of rain blown by the wind, puffs of air, whether coming singly or at regular intervals like small waves, some of which it will appreciate, or the finer and more delicate waves of radiant heat. It will be seen at a glance from Figs. 5129 and 5130 that if we but choose such disturbances as travel only in straight lines, we shall have already an instrument that will estimate direction with a good deal of precision, for on the forehead we can distinguish between two irritations that are taking place within one centimetre of each other, and the area of the surface exposed being about twenty-eight square centimetres, we shall have at least twenty-eight distinct sensations that will indicate with certainty as many directions that may be occupied by the body originating the disturbance. It seems almost impossible to imagine that one should be constantly using one's judgment about the significance of impressions of this kind, without very soon doing it in an automatic way without the activity of those cells that preside over consciousness being excited; this is quite in keeping with what goes on in regard to other things. No one who has learned to read, to write, to walk, or to ride on a bicycle, but can recall the various stages passed through in some of these acquirements, from the time when the work was wholly directed by the intelligence, and laboriously directed, too, until the time when we read, we walk, we ride, and do not know how we do it, and do not even know that we do it. Ideas come to us from the printed page, for hours at a time, without our having the slightest consciousness that we are using syllogisms, that words are intricate combinations that stand for sounds compound in their nature and complex in their significance, and which we were once obliged laboriously to decipher, although now we do the work without the slightest consciousness that there are such things as words, or books, or ink, or paper. Further illustrations are as unnecessary as they are abundant, and they all teach us that all mental operations that can be made a matter of routine and precedent become unconscious operations, and the world presents itself to us as a vivid and real thing of such a nature as it has proved itself to possess by intellectual processes after these processes have reached the end of the beaten track, whether that track has been worn to the end of the finger or to the end of the street. It remains only to show that the eye is an instrument whose measuring functions are so accurately performed that they never mislead in their indications of what exists in visible space, though they never suggest to us that there are such things as images on the retina; and the wonder becomes, not that we should see a thing where it is, but that we have ever found out that there is such a thing as a picture of it on the retina.

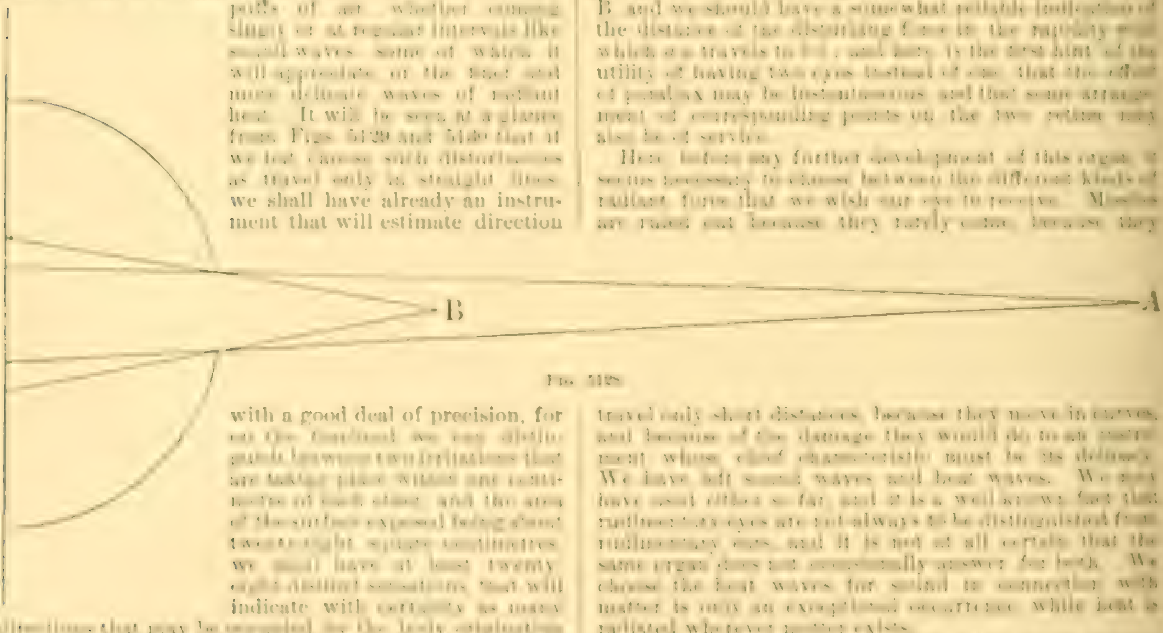


Fig. 5128.

Returning now to the diagrammatic eye as shown in Figs. 5128, 5129, and 5130, we have in this clumsy instrument the first suggestion of an ability to estimate depth as well as direction. In Fig. 5128 it will be seen that forces coming from a point near the eye, as at B, will impinge upon a larger part of the sensitive surface than those coming from the point A, which is farther removed. But this is of doubtful significance, as a number of points near A (Fig. 5129) would produce about the same effect as one point at B; but if the eye were moved from side to side, the position of A, in Fig. 5130, would change as that of B, and we should have a somewhat reliable indication of the distance of the disturbing force by the rapidity with which one travels in [illegible], and here is the first hint of the utility of having two eyes instead of one, that the effect of parallax may be instantaneous, and that some arrangement of corresponding points on the two retinæ may also be of service.

Here, before any further development of this organ, it seems necessary to choose between the different kinds of radiant force that we wish our eye to receive. Missiles are ruled out because they rarely come, because they travel only short distances, because they move in curves, and because of the damage they would do to an instrument whose chief characteristic must be its delicacy. We have left sound waves and heat waves. We may have used either so far, and it is a well-known fact that rudimentary eyes are not always to be distinguished from rudimentary ears, and it is not at all certain that the same organ does not occasionally answer for both. We choose the heat waves, for sound in connection with matter is only an exceptional occurrence, while heat is radiated wherever matter exists.

We have used the term heat guardedly, for heat as such is perceived by the sensory nerves of the skin, and the heat waves and light waves are not merely similar, but they are absolutely identical. This is a well-known fact in physics, though it is often ignored or passed over lightly in elementary books; and as the eye is supposed to develop from a surface that is well known to be sensitive to heat as heat, and as the pigment spot which is usually present increases the heating effects of the ray, it is not improbable that the heating effect of the ray has much to do with the early growth of the organ.

We will then accept the choice that nature has made for us, and hereafter we will exclude all other disturbing elements, and consider that the eye is adapted to the reception of those waves that fall between A and H, as designated by Fraunhofer.

Next, suppose we place in the aperture of our cup-shaped organ an arrangement that will cause all rays that pass through it, after diverging from a point, as in Figs. 5131 and 5132, to converge to a point on our sensitive surface that corresponds to the retina. Such an arrangement is the lens that we have in the human eye, and it must needs change its shape to correspond to every different distance of the point of radiation, and, as is well known, it must be of greater thickness for B in Fig. 5131 than for A in Fig. 5132. This change being dependent on voluntary muscular action, the force of which we are able to feel, we have now the ability to judge much more accurately concerning depth or distance, that is, concerning the length of the line ρ in Fig. 5126, by the effort that is necessary to make the spot on the retina as small as possible.

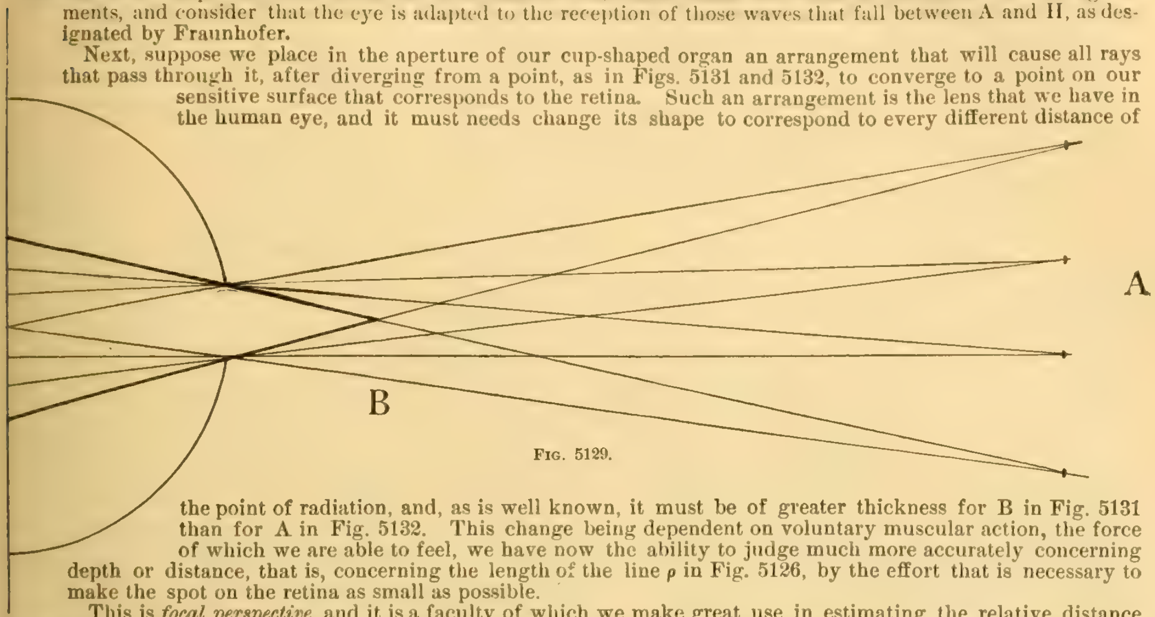


FIG. 5129.

This is *focal perspective*, and it is a faculty of which we make great use in estimating the relative distance of objects that are less than twenty feet away. Beyond that distance, changes necessary in the lens are so small that we cannot appreciate them. The eye has also, since this last modification, acquired two other methods of estimating distance, by which it can reach out still farther into space and make unerring inferences. One is *mathematical perspective*. It depends upon the fact that any number of points situated near each other in space are represented on the retina by a similar number of points similarly arranged; and though our personal experience never allows us to find out about these retinal points, the sensations caused by them are distinct in their character, and unerring in their significance regarding the position of the points that are causing these latter by their radiations; and if we or our ancestors have ever had the ability to locate the originating points consciously and theoretically, it follows that we must, in accordance with all experience in similar matters, soon come to locate them unconsciously, after our experience has been such as to establish the trustworthy nature of our deductions; and we locate them in space because we find by experience the cause of them in space; and we do not locate them on the retina because we, in our personal experience, have never had any reason to think that we have a retina, much less a geometrical arrangement of points on it. This sensory surface, which is fast developing into a retina under our guidance, is not only able to recognize difference as in the location of the light points, but has become extremely sensitive to gradations in the intensity of the irritations that are directed to it; and as all points which mark the special limits of material objects are likely to vary in their light-giving qualities, and as none of these variations are matters of chance, but many of them depend on the shape and situation of the bodies themselves, we have in the eye as here constructed an instrument that is quick to detect the changes of form in the retinal image, though it cannot recognize them as such, but must attribute them to a changed arrangement in the outlines of the body that is the source of the disturbing radiation.

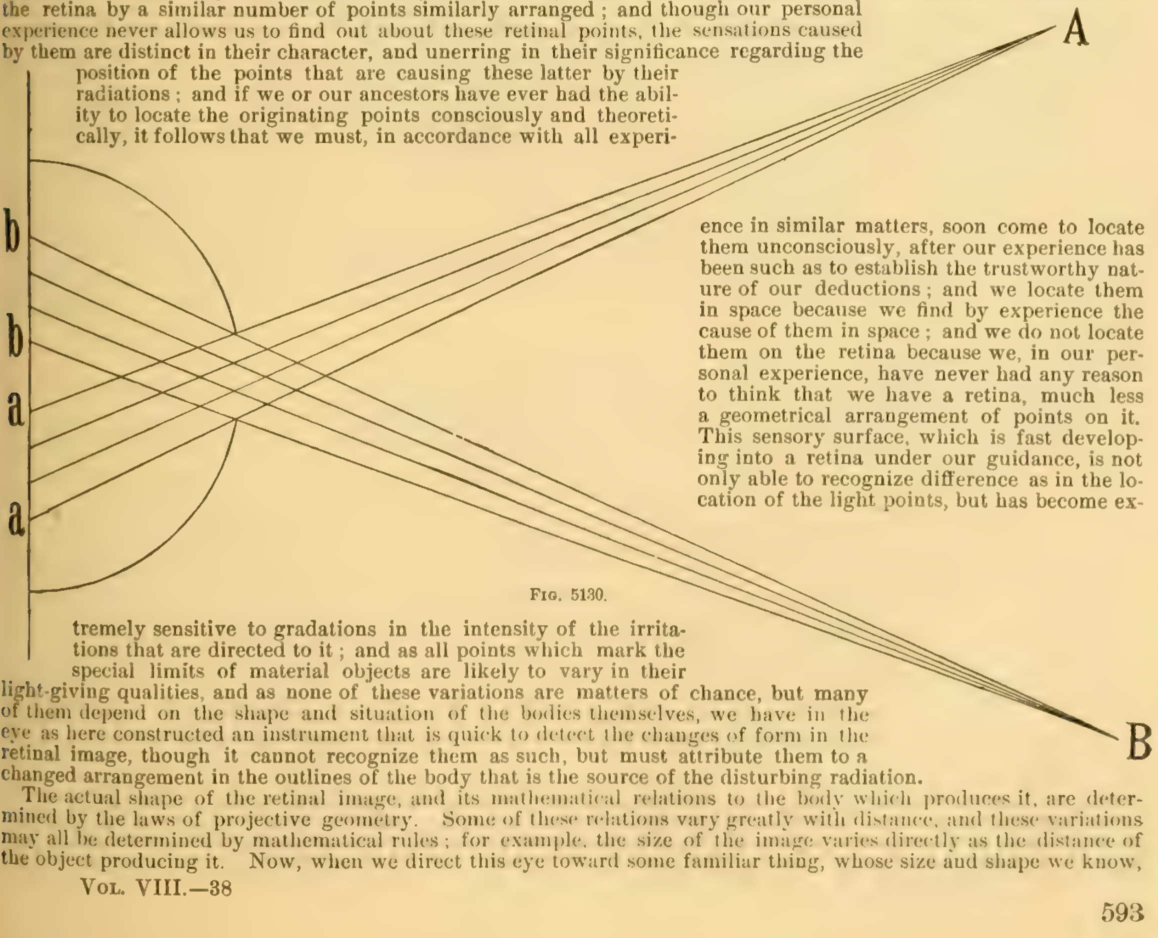


FIG. 5130.

The actual shape of the retinal image, and its mathematical relations to the body which produces it, are determined by the laws of projective geometry. Some of these relations vary greatly with distance, and these variations may all be determined by mathematical rules; for example, the size of the image varies directly as the distance of the object producing it. Now, when we direct this eye toward some familiar thing, whose size and shape we know,

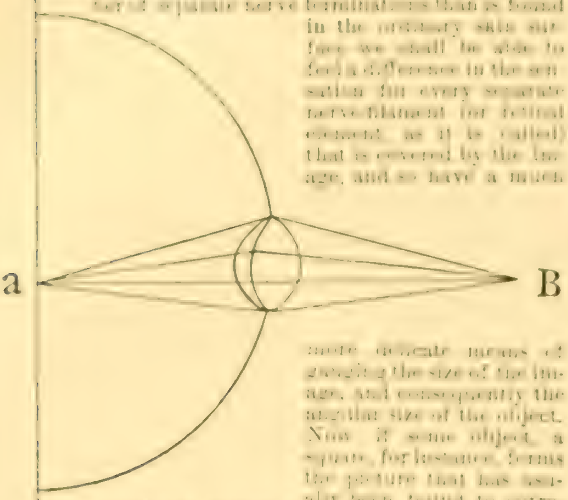


Fig. 5151.

experience teaches us that certain changes in its apparent shape from what we really know it to be are dependent wholly on distance; and if we have, as in Fig. 5151, a much larger number of separate nerve terminations than is found in the ordinary skin surface we shall be able to feel a difference in the sensation for every separate nerve filament (or retinal element, as it is called) that is covered by the image, and so have a much more delicate means of gauging the size of the image, and consequently the angular size of the object. Now, if some object, a square, for instance, forms the picture that has usually been found to correspond to a square at a certain distance, we see it as a square at the distance at which it has heretofore been proved to be. It may not be a perfect picture of a square, but if it is nearly enough so to be decidedly suggestive of a square, and the only difference is that one side of it does not seem to be quite long enough; after we have found out that it ought not to seem quite long enough if it is a little farther off than the other side of the square we shall soon get to recognize that it is a square, but that one side is a little farther off than the other; and after a time this will not be the result of deliberation, but it will be our first impression, because that philosophic process has become a matter of intellectual routine and is dispensed with or attracts our attention no more. These impressions, which are in adults instantaneous, are what we know as *mathematical perspective* because they are impressions that are caused by a practical though not necessarily a theoretical, mathematical knowledge of the situation. The fact that our habit of unconsciously making allowance for the mathematical perspective continually warps our judgment in regard to the real shape of the picture on the retina will be readily appreciated by any one who has taught drawing from nature, and found the difficulty of making pupils draw what they see instead of what they know is really before them; and this too illustrates how quickly the consciousness ceases to interest itself in the application of general rules that have been found to be invariable. We have also in the eye a power to appreciate what may be called the translucency of the stereoscopic picture and which will be mentioned later. Thus, if we direct the eye toward three points in the same straight line, but at such different distances that when the middle point is focussed the other two will make comparatively large circles of diffusion on the retina, and if the angular distance of the points be very small these two circles of diffusion will overlap each other and also overlap the middle point that is distinctly focussed, and the retinal picture as well as the visible picture will be like Fig. 5154; then as we get the parallax by moving the head a little from side to side while the eye is fixed upon the point, the smaller circle will move as we move the head and the larger in the opposite direction. This will suggest to us that the smaller circle is behind the point and that we see the point through the larger circle. This phenomenon also suggests depth, at first through our intellect, afterward instantaneously; and in this way we can analyze the impression which we get in looking at an object in front of or behind a dingy glass, or a transparent screen or netting. *Aerial perspective* also gives us a criterion by which to judge of distances that are greatly different.

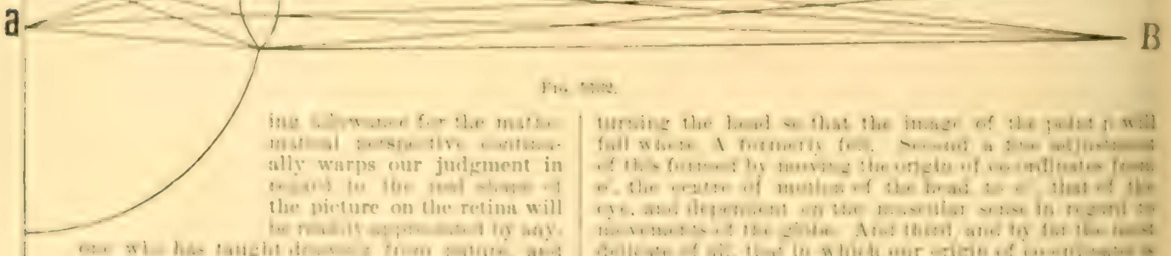


Fig. 5152.

The opacities of the air cut off the light, and the irregularities of density change its direction so that points and lines cannot be accurately focussed; and, in consequence, coarseness and irregularity of outline also suggest distance and vary with the distance.

It will be an easy step now to make the transition from the instrument that we have imagined ourself to develop from the skin to a fully formed human eye (Fig. 5153). The shape has somewhat changed, the concavity of the retina being nearer the shape of the real image that it receives than a flat surface would be. The number of elements in the retina are immensely increased, so that the ability to estimate angular magnitudes is in its most sensitive part delicate enough to appreciate fractions of a second. The whole organ is made mobile, and furnished with muscles that will direct it to any source of radiant disturbance, and through the ages it has acquired so many methods of judging of distance—that is, of estimating the line *ρ* as well as the angle ω—that through it we get the most definite and trustworthy information of the outside world, while we get no information as to what is going on on the sensory surface itself. Let us review the situation, and see what we have in the normal eye as far as ability to judge of space relations of external objects is concerned; that is, what power we have at our command for obtaining accurate information of the position of objects in space, using our polar coordinates for the description of positions, and remembering that form is entirely dependent on position. Considering Figs. 5155 and 5156, we shall see that for measuring the angle ω, or the angular distance of p from any point A, there are three methods. They may be named as follows:

First, that dependent on the muscular exertion of turning the head so that the image of the point p will fall where A formerly fell. Second, a fine adjustment of this former by moving the origin of coordinates from o, the centre of motion of the head, to o', that of the eye, and dependent on the muscular sense in regard to movements of the globe. And third, and by far the most delicate of all, that in which our origin of coordinates is placed at o'', the nodal point of the dioptric system, and the arc $A''\,p''$ is measured by the number of retinal elements that are included between the points where the lines $p''\,o''$ and $A''\,o''$ cut the retinal surface.

For the determination of the length of the line *ρ* we have more but less accurate methods. First, in *focal perspective*, connected with the muscular sense in the adaptation of the lens to the distance, so that small and distinct images can be obtained. Second, in the transparency of the circles of diffusion, or our ability to see through images or parts of images that are indistinctly formed, and our disbelief in the possibility of having two objects occupy the same place at the same time. Third, in *parallax*, a practical knowledge of the relative changes in angular distance that will be produced, in bodies at different actual distances from ourselves, by change in our own position. Fourth, *mathematical perspective*, or a knowledge of the discrepancies that a difference of actual distance may cause in the results obtained as above, when compared with each other or with what we know is the actual state of the case by experience obtained through the other senses. And fifth, *aërial perspective*, or the changes due to a lack of transparency or homogeneity of the medium through which the object is seen. It is thus seen that we have for the angular distance, as when we stand at O and estimate the distance A P, in Fig. 5126, accuracy to within a fraction of a second.

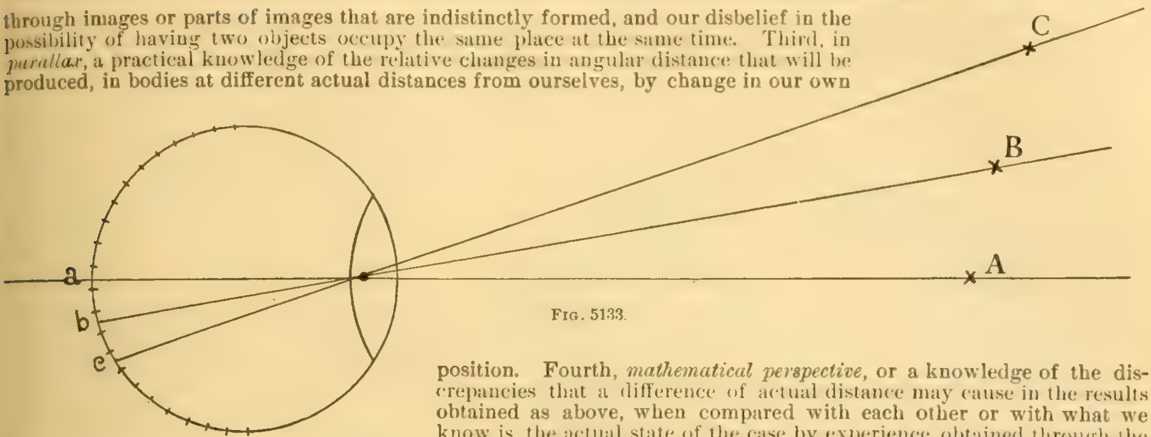


FIG. 5133.

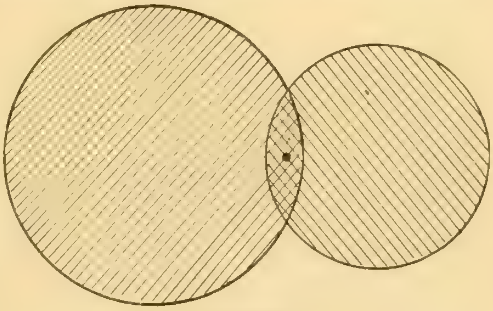


FIG. 5134.

For the measure of the actual distance of an object from ourselves, as of O from A or from P, we have no one method at all comparable for accuracy to the above, in which, by the mobility of the eye and the fine distribution of retinal elements we have five different methods, each one of which produces its own impression as to the length of the lines, and by combining them we have a resultant that should be expected to compare in accuracy to those obtained from all our other senses put together.

When we compare the sense of sight to that of sound, we cannot wonder that our impressions of space that are gathered from the former sense should be quite as vivid and precise as they seem to us. In listening it is highly probable that the ear is put in one and the same condition for sounds from all distances, uniaural adjustments being only adapted to the estimation of pitch and intensity, neither of which are invariably dependent on distance, so that we have nothing that corresponds to focal perspective; and though we are perhaps as well off in regard to the aërial modifications as in the eye when we compare definite sounds with definite points of light, we lose all this advantage, or, at least, nearly all, from the fact that audible vibrations are of extremely rare occurrence, while every point in the boundaries of material objects is a source of those vibrations by which the eye may judge of distance; and this judgment is immensely aided by comparisons that can be made, at the time of the effect produced, by any one point or any series of points, and that produced by others, and we scarcely open our eyes but there is presented to us examples, visible points, lines, and surfaces, situated at any and all distances that we can imagine to exist, and we can note and do, both consciously and unconsciously, the gradation of these effects one into another, especially in looking at lines and surfaces, whereas in sound we have nothing of this effect, except where the element of time is added we may, as when a moving sound dies away in the distance, realize it by the variation of intensity.

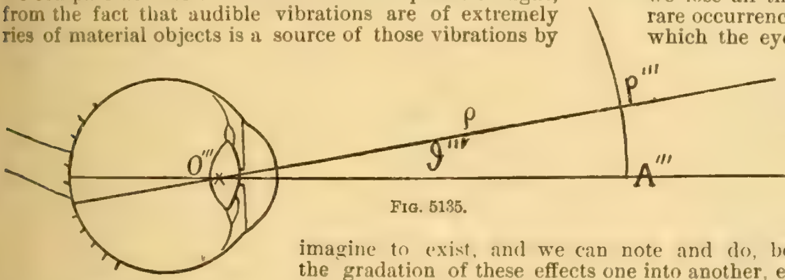


FIG. 5135.

If the writer has succeeded in setting forth in an intelligible manner the very important part that is played by a single eye in giving us instantaneous ideas of the space relations of distant objects, he feels that a great deal has been done preparatory to the study of binocular vision, which is only a study of the method by which two eyes refine and intensify the ideas of solid space which we receive in great measure from one eye alone.

He will apologize, if apology is necessary, for devoting so much attention to a single eye, but he feels sure that the binocular function cannot be understood and appreciated without a comprehension of the fact that there is such a thing as uniocular stereoscopic vision, the theory of which needs to be more thoroughly examined than it ordinarily is in elementary works.

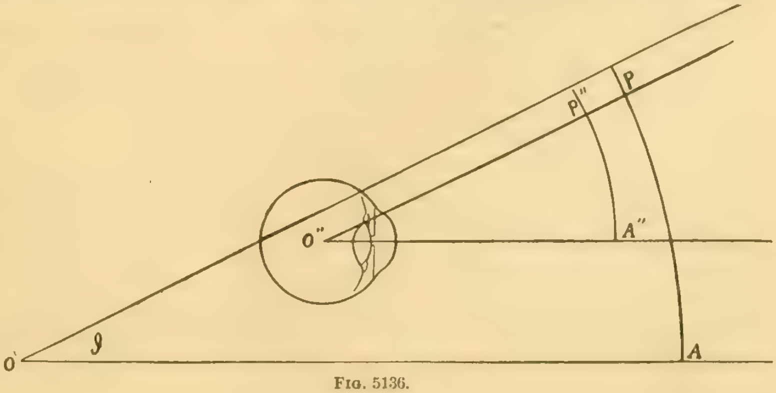


FIG. 5136.

The perpetuation and present existence of a binocular system in all the higher orders of animals is probably due to the fact that by it the field of vision is enlarged. It

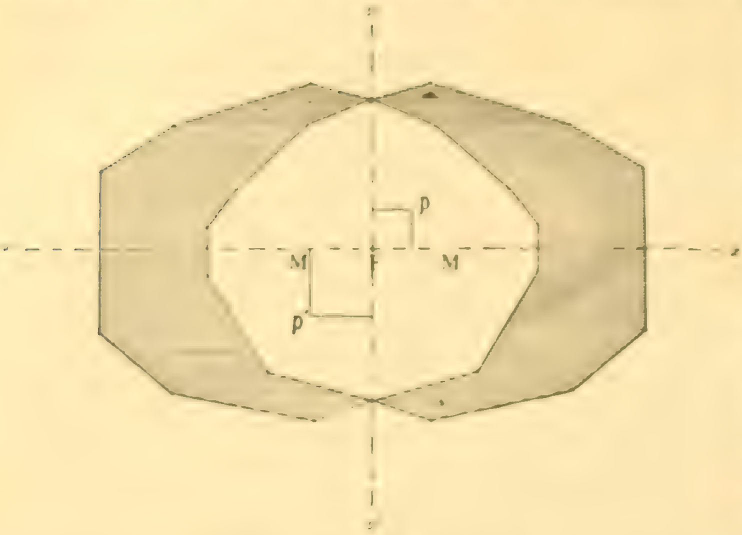


FIG. 5137.

is highly probable that in many animals this is the only advantage, and that the fields do not overlap, but that the one begins on the picture somewhere near the place where the other leaves off, and so the binocular field is just double the extent of the uniocular. In this case there is no more need of confusion from the existence of double images than there would be if the animal had a cyclopean eye of double the angle of aperture. In the eyes of those animals where the fields overlap a little, and some objects at the extreme front are seen with each eye, it is impossible for us to believe that the animal would be deceived for any length of time into thinking that there were two objects instead of one, and it is natural for us to suppose that the central point of that part of each field which is overlapped by the other should be the one on which objects that were immediately in front of the individual would be focussed, when the eyes were at rest and were not making any special effort to see. Fig. 5137 represents the two fields of the human eye taken when the eyes are so directed that the axis of symmetry of each eye is very nearly identical with the general direction of the axis of the orbital cavity. The centre of the right field is at M, that of the left at M, and these two points are at an angular distance of about twenty-five degrees, this being a little less than the inclination of the orbital cavities. This diagram also just as truly represents the sensitive surfaces of the retinæ seen from behind as one looks at the focussing plate of a camera, and overlapped as they would have to be to receive the same retinal image from one lens that they now receive from two. Any point of light directly in front of the observer and at a great distance away, will, of course, fall upon the point F, and F will have the same anatomical situation on each of the retinæ; and in the neighborhood of this point is the place where most of those images would fall to which we desire to give particular attention. Now, following the same laws that have been so particularly insisted upon in the last section concerning vision with one eye, and which now may be taken for granted, it is impossible to suppose that we should fail to recognize that there was only one object to correspond to the sensation that was caused by the simultaneous excitation of both retinæ at those points where they would be most likely to be affected at the same time. As this is the point near which the images of objects in the "approaching view" will naturally fall, and will be focussed at first without any effort on our part, it is of course the point at which the function of vision will be most frequently exercised and most carefully cultivated, and this is in fact the point where the retinal elements are the most numerous and the most sensitive. Further, if the point F be taken as the origin of coordinates (rectangular Cartesian coordinates are the most convenient for our purpose here), we can plot out by the laws of projective geometry the exact positions that the different parts of the retinal pictures will occupy if they are caused by distant objects in the binocular field. It is evident at a glance that those points that fall on the axis $y\,y$ will be the only ones that will have the same anatomical position, while all others will be as far to the inside on one retina as they are to the outside on the other. The points on the two retinæ that correspond to the same coordinates are called corresponding points, and objects forming images whose positions are marked out by corresponding points on the two retinæ are seen as one. This is *the law of corresponding points*, and was first stated, as far as we know, by Alhazen, an Arabian philosopher who flourished about A.D. 1100. Vision, as ordinarily measured by test letters in the binocular field, is undoubtedly more acute when both eyes are in use, but the difference is so slight that it is hardly worth noticing. A change amounting to five per cent. in the dimensions of the object looked at, or in the illumination, will probably more than compensate for the loss of one eye under these conditions; but in the estimation of actual distance

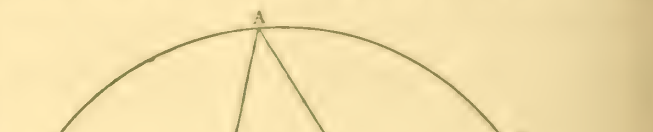


FIG. 5138.

of the object from the observer, the advantage that two eyes have over one is very great. Let us suppose now that we have finished with our rudimentary experimental eye, and that we have two eyes fully formed and well developed into their present condition, as they now exist in the human species, and that we are thoroughly acquainted with the abilities of each in a unocular way. Remembering that they are surveying instruments, and that in their natural situation one is permanently placed at each end of a base line which is in the same individual practically fixed and unchangeable, and in the adult is between six and seven centimetres in length (see Fig. 5138), S D representing the base line or the intra-ocular distance, which, without any great error, we may assume to be the same whether it is measured between the nodal points or the centres of motion of the two eyes.

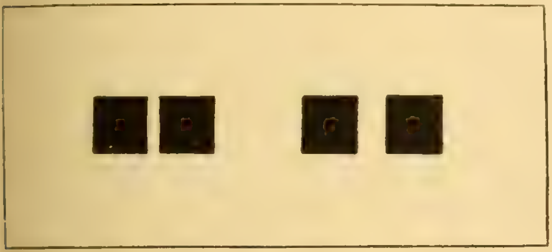
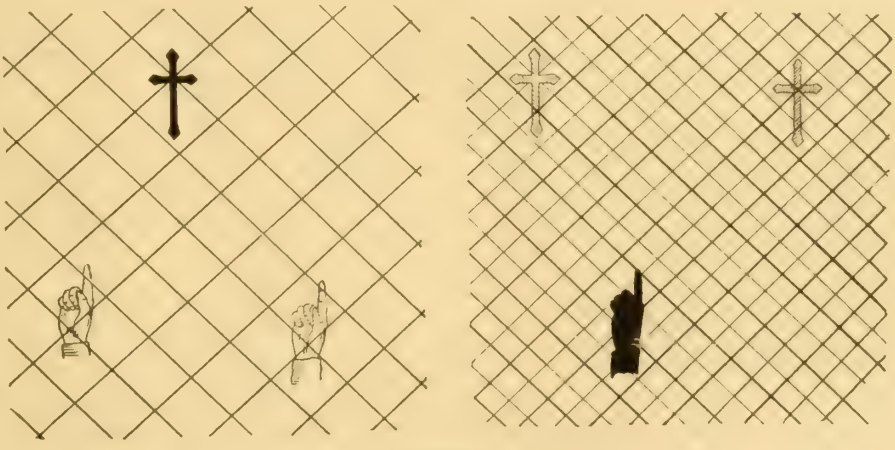


Fig. 5139.

Let a and a′ be the most acute part of the retinal surface, viz., that part which is likely to be the most thoroughly cultivated in any animal that has the power of locomotion, because it is the part naturally turned to the approaching landscape when the eyes are at rest. Remembering the law of corresponding points, it will be seen that if the attention is directed to any near object as A, it will be necessary to turn the eyes inward, so that the visual axes will make at the points S and D two angles that are together less than a right angle, these two angles being practically right angles for distant objects. The estimation of the perpendicular distance of A from the line S D becomes an easy problem in surveying, it being a trigonometric function of the angles A S D, and A D S, and the magnitude of each of these angles is quite accurately estimated by the muscular sense of the force required to converge the eyes so as to bring the image of A on corresponding points and on the most sensitive portion of the retina. That the appreciation of the amount of muscular convergence is an important element in the binocular estimation of distance, is well shown by Fig. 5139, which is a reproduction of a stereoscopic card published by Dr. John Green in the "Transactions of the American Ophthalmological Society" for 1889, illustrative of the fact that the slight amount of convergence that is necessary to superimpose the two right-hand squares is enough to overpower the impression made by all the other conditions combined, and to convey to us the idea that the right-hand square is both nearer and smaller than the left, though this is not at all the case. Hence we may put it down as a fact that one of the chief factors in the binocular estimation of distance is the amount of convergence necessary to bring the two images over corresponding points of the retina.



A Fig. 5140. B

Note.—All the reproductions of stereoscopic pictures in this article may be seen as they stand in the book, by changing the direction of the optic axes so as to obtain just that amount of diplopia, either homonymous or heteronymous, that will bring the right-hand picture of one eye over the left-hand picture of the other. Anyone who has not acquired this art may readily do so with the help of a No. 2 prism (base out or in as the case may be), the relative distance of the different objects being exactly reversed as the díplopia is made homonymous or crossed.

Before going farther it will be necessary to make some inquiries into the nature of the sensations produced by objects so situated that they do not produce images that fall on corresponding points. Perhaps a single experiment will be sufficient for our purpose. If we point with the forefinger at some distant object, a cross on a figured wall for instance, and look at the cross at the same time, we shall see it distinctly, but we shall also see, if we have self-control enough to prevent our eyes following our thoughts, that there are two fingers pointing at the cross instead of one. One of the fingers will seem to be directly in front of us, and the other will be seen a little to one side, or it may be that we shall see the cross in the distance directly between the two fingers. Those of us that have had the pleasure of being boys and using bean-blowers, have a distinct recollection of taking aim between two apparent tubes when we really had but one in our hands. These indistinct images of the finger that we see hide nothing, because of the different relative positions occupied by the two eyes, that which it hides from one not being hidden from the other (see Fig. 5140, A). If now, without changing our position, we look at the finger, we shall see that distinctly, it no longer being doubled, but we shall also see two crosses, and the figured wall in the distance will also be doubled (see Fig. 5040, B). Nothing on the wall will be hidden from us because that which is covered up in one image of it will be uncovered in the other, and one eye will see what the other does not. This is a phenomenon which reminds us of the transparency of the circles of diffusion in uniocular vision, though it is much more marked. However, it is a thing which quite a number of people have never noticed, and which some few cannot be made to see. The position of the eyes and the objects in this last experiment is seen in Fig. 5141, where C corresponds to the finger when we look at the cross at B, and where A corresponds to the cross when we look at the finger at B; A, B, and C representing objects at three different distances in front of the observer, and in the same—nearly horizontal—straight line a little below the level of the face. Each eye is supposed to be looking at B, and when so doing C is seen faintly on the left by the right eye, and faintly on the right by the left eye; while A is seen faintly on the right by the right eye and on the left faintly by the left eye. This apparent doubling of the object is called diplopia. When the apparent place of the object as seen by the right eye is on the right of where it ought to be, and that of the left on the left, it is called homonymous diplopia; when the object as seen by the right eye is on the left of its true position and that seen by the left is on the right, it is called heteronymous or crossed diplopia; and from Fig. 5141 we can establish a general law that all objects beyond the point toward which we direct the visual axes will be doubled homonymously, while those that are nearer than that point will be doubled heteronymously. Fig. 5142 presents the appearance of the three objects A, B, and C arranged as in the last figure when the eyes are looking directly at B. B is seen distinctly, while C is doubled, and each of the apparent Cs are seen more faintly and neither of them completely hides what is at a considerable distance beyond it; and the apparent A is also doubled, the As being seen somewhat indistinctly, and nothing on the plane surfaces perpendicular to the visual axes at the same distance as A is entirely hidden by B or C. When the eyes are directed toward B there are other points in space where objects may be placed so that they will form images on corresponding points of the two retinæ, but these places are not directly behind or in front of B. They are situated either above or below, or toward one side, and the locus of these points is called the *horopter*, of which something more hereafter.

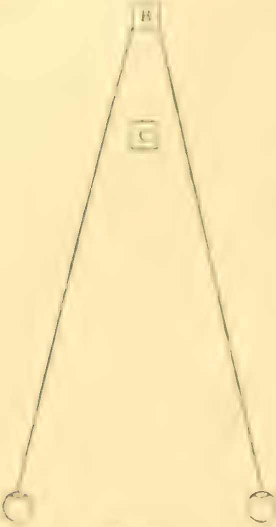


Fig. 5141.

One other, and a highly important, fact must also be mentioned before we have the data necessary to follow out the methods by which we obtain binocular impressions of space. It is this. The laws of projective geometry teach us that any solid bodies that are differently situated in regard to the two eyes must generally produce two retinal images that are not absolutely identical, and the dissimilarity will have an inverse relation of some sort to the length of the perpendicular distance from A (Fig. 5138) to the base line S D as compared with the length of the line S D. That this difference which must necessarily exist between the two pictures had something to do with the perception of solidity in space was probably known to Leonardo da Vinci. He is credited with having had some appreciation of the facts, but they did not attract much attention in the scientific world until the days of Wheatstone, who again called attention to them, and proceeded to demonstrate that, hidden behind these two dissimilar pictures, might be found the germ of much that even to this day goes by the name of binocular vision. He did this by the invention of the stereoscope, an instrument by which that difference which exists in a marked degree between the appearance of the outside world as viewed by two eyes and as viewed by one eye alone, is so completely simulated that no one since has been disposed to doubt the radical truth of his views.

The stereoscope is an instrument by which two pictures, both drawn on a plane surface, and differing from each other just as two projections of solids or groups of solids would differ when projected on the same plane surface through two points as differently situated as the two eyes usually are. Let us illustrate by a somewhat exaggerated picture. If we hold a small book with the back toward us about one foot in front of the face and in the median plane that divides our face symmetrically, and if we look at the book with the right eye we shall see something like R in Fig. 5143, but if we look at it with the left eye we shall see it as it appears in L. The same difference in the two pictures will appear in a less degree if the book is at a much greater distance from us than it is in this particular case. We shall see the back of the book with both eyes, and the pictures on the retinæ will be similar in this respect, or nearly so; but with the right eye we shall see the right side of the book, which is entirely invisible to the left eye, and with the left eye we shall see the left side, that is entirely invisible to the right eye. Each of these pictures is exactly like the projection on a plane surface perpendicular to the visual axis and situated anywhere between ourselves and the book. Now, if we direct our attention to the back of the book, we shall see that distinctly, and it will appear single because it will in the main form retinal pictures on corresponding points; the rest of the book, that is, the two sides, will not be seen as distinctly, for their pictures do not fall on as sensitive portions of the retinæ, and we shall see the two sides in two different places from what we know them to be. We may not notice this if our attention is not called to it, but if we look carefully and analyze the sensations that we are receiving, this book, that appeared to us as one solid book shut together and confined as closely as its thickness would permit to the median plane, will be two books somewhat shadowy and having a common, real-looking, and apparently solid back as it appears in L-R. If now we direct our attention to the further extremity of the top of the book, which seemed indistinct and double before, we shall see that as in R-L it is no longer dim and indefinite, but it is now single as it ought to be, while the back that is toward us is now double, and we half feel as if we saw parts of each side through the other. Besides all this, the book does not seem to hide the things in the room beyond it. We do not think of it as being transparent, but whatever we look at a little distance beyond the book can be plainly seen, sometimes through one of the books (it has now become entirely doubled), sometimes between them or off at one side. All these things we can see with a distinctness corresponding to the part of the retina on which their picture falls, if we keep our eyes fixed on the book itself. This practical transparency is enough in itself to suggest that the book is in a different plane from other things that seem to be behind or in front of it and can be seen at the same time. Life-long experience when the real distance of the two objects

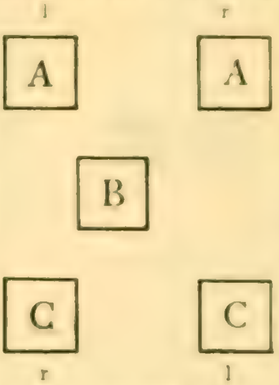


Fig. 5142.

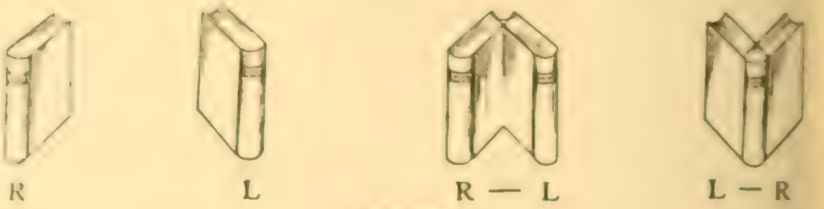


Fig. 5143.

looked at was the same, has only produced this effect in case of certain exceptional substances, glass for instance. The double outline of one part of the book, when we look at the other, is also a phenomenon that is almost entirely confined to appearances connected in our experience with solidity. Referring again to the experiments with the hand and the cross, let us review the binocular phenomena thus far studied. We have the muscular sense necessary to convergence when we direct each visual axis to the thing looked at. With the hand and the cross (Fig. 5140) we see that two objects that are situated at different distances in front of us cannot both be seen singly at once, and by comparing with Figs. 5141 and 5142, we see that the further object is doubled homonymously, and that the nearer is doubled heteronymously, while that at which we look is seen singly. We see also that nearer objects do not necessarily, if small, conceal the more distant ones—what is true of them as above stated is also true of different parts of the same object. In these four facts we have all the important data needed to explain the superiority of binocular over uniocular perception of space relations. No one who has binocular vision will hesitate to say that the difference between the view as seen by one eye and by two is strikingly vivid, as, considering these advantages, it ought to be. In convergence we have, of course, a great improvement on the parallax. In the doubling and the transparency of the images we have that of which the looking at objects from different positions, and the blurring of their edges from circles of diffusion, is merely a hint.

Great as these advantages are, singly or together, it has not always been a matter of universal agreement as to which played the most important part in giving the added usefulness. Wheatstone, the inventor of the stereoscope, asserted that our perception of the third dimension in space was to be explained in this way: That the two eyes receive two images slightly different on each retina, and the two images are fused by mental processes. This is the first great step that was taken in the scientific development of the subject, and it contains the gist of the whole matter. Just what Wheatstone's ideas were and how expressed, the writer is not at the present moment able to state, but the idea of mental fusion seems either not to have been so broadly and comprehensively used, or else to have been so little analyzed and explained, that it was not accepted without criticism. Professor Le Conte, in a somewhat recent book, says of this theory, "It makes simple and primary that which is capable of analysis into simpler elements." This is undoubtedly true, but whether in the act of seeing this analysis always takes place before or while we are experiencing the binocular perceptions is a question that may be considered as to-day open to argument. If, whenever we look at solid objects, our visual sensations are varied from uniocular sensations simply by the fact that there are two slightly varying pictures which nearly but not quite fit the corresponding points, there does not seem, in the light of modern ideas in matters of mental physiology, much reason to doubt that our appreciation of solidity would be increased considerably whether we were able to analyze and systematize the variations or not. After Wheatstone, the experiments of Brücke, Brewster, and Prevost proved that the double images are not ordinarily so completely fused that careful attention to the appearances does not enable us to appreciate that they exist, and so produce consecutively single vision for all points in the binocular field, even if they are not included in the same horopter. This school taught that this state of things is somewhat appreciated in a functional way, and that the eyes are in a state of unconscious changing, the adjustment being rapidly altered to fit various different points in turn, so that the resulting impression is a feeling of depth equivalent to the requisite amount of change. This theory may be considered to be an advance on that of Wheatstone, not on account of its disproving that, but because it gives additional detail, and analyzes a process that undoubtedly goes on in certain cases; but the theory is wrong as teaching that this process of continued change from one point to another is a necessary or constant part of binocular vision. The fallacious part of this theory was afterward shown by Dove, who proved experimentally that the binocular stereoscopic effect may be instantaneously produced, and does not need the time necessary for the execution of these movements. It was asserted by Dove, and has been abundantly verified by experiment, that the illumination by a flash of lightning or by a spark from a Ruhmkorf coil, the duration of which is so exceedingly short—less than one two-thousandth of a second in some cases—that the idea of changing the adjustment of the eyes is out of the question. Still, there is no doubt that we do at times reassure ourselves in this way in regard to a stereoscopic effect; anyone in experimenting with binocular vision will do so many times consciously, and will catch himself in the act af doing it often enough to believe that this act may be sometimes a part of the process by which we get an appreciation of space, which appreciation the writer believes is a sort of visual resultant dependent on no one thing for its characteristic sensations, and from which process almost any one factor may be eliminated without materially changing the result.

It having been proved by Dove that the rapid change of the images on the retina is not a necessary part of the stereoscope's function, it remains to study the images as they exist in an instant of time. This has been done by Helmholtz and others, and the results of their advance in physiological explanations are thought by some to demonstrate that the binocular perception is in the main dependent for its explanation on the phenomena which have been referred to, principally in this paper, in connection with the hand and the distant cross (Figs. 5140, and 5135 and 5136). Le Conte in 1871, and again in 1882, expresses his "own" view of the case as follows: "All objects or points of objects either beyond or nearer than the point of sight are doubled, but *differently*—the former homonymously, the latter heteronymously. The double images in the former case are united by *less* convergence, in the latter by *greater* convergence, of the optic axes. Now the observer knows, *instinctively and without trial*, in any case of double images, whether they will be united by greater or less convergence of the optic axes; in other words, the *eye* (or the mind) *instinctively distinguishes homonymous from heteronymous* images, referring the former to objects beyond, and the latter to objects on this side of, the point of sight. Or, again, in case of double images each eye, as it were, knows its own image, although such knowledge does not emerge into distinct consciousness. . . . This is all that is necessary for the perception of relief. But it is probable—nay, it is certain—that the relief is made clearer by a ranging of the point of sight back and forth, and by a successive combination of the different parts of the object, or scene, or pictures, as maintained by Brücke."

We have now followed the theoretical development of this interesting subject from the time of Alhazen to the present day. Most of the side issues have been for the time being completely ignored, but before proceeding to speak of one or two of those interesting questions, it will be wise for us to ask again, What is binocular vision, and on what, after all, does it depend for the important place which it has occupied in mental and ophthalmological literature.

That there is something worthy of a name and a class by itself cannot be doubted by anyone who has had the pleasure of looking through a stereoscope at some of the striking cards published by Dr. Green—for instance, that which was reduced to form Fig. 5144, in which the appearance of relief is so startling and unexpected that it would seem impossible, for anyone who had seen it stereoscopically, to notice anything about it so much as the change brought about by the fusing of the two pictures. To this plate, printed to illustrate how a single one of the conditions that contribute to our perception of relief may be sufficient to overbear any or all of the others, we come with entirely unprejudiced attention. The word Helmholtz on each side of the card is printed with what seems to be most ordinary type, that might have type, and I doubt not the same from the regular stock of some ordinary printing establishment; and anyone would expect, in looking into the stereoscope, to see something very like what is seen by either eye on either side, with perhaps a little blurring where the pictures do not quite coincide; but the first impression as the pictures are superimposed, whether by looking through a stereoscopic apparatus, or by diverging the optic axes, is that the whole word is not at all indistinct, but that it has tipped forward at least forty-five degrees, and while the bottom of the letters remains on the paper, the top of each letter is much this side of where it was before. The difference between the pictures as seen with either eye, and with two together, is so decided and so obtrusive that one does not feel justified in finding much fault with the assertion that it is principally through binocular vision that we get our most decided visual perceptions of the solidity of space. But it is quite certain that these perceptions are not entirely and always due to the binocular arrangement, and that they are not in all cases to be attributed to the same condition or combination of conditions.

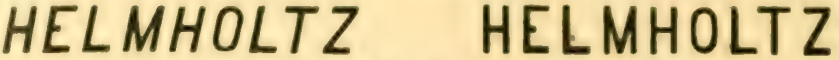


Fig. 5141.

We have considered in turn each one of the methods by which it would be possible for a conscious thinking person—a person of intelligence—to judge of distance by carefully attending to the differences in the sensations that he is capable of receiving through the visual sense. We have seen that in our practical, every-day experience these sensations have varied in such a constant relation to the distance that, with perceptive faculties such as we are known to possess, we could arrive by logical processes at very definite and accurate estimations of space relations. We know that for untold ages our ancestors have had the ability to arrive at these definite conclusions in regard to position in this same way. We know also that the human mind is such that logical processes that are continually repeated, for definite purposes and with definite and unvarying results, cease to go on under the domain of consciousness, if they go on at all; but the results are reached with as great or greater accuracy than if they continued; and we know also that this ability that exists in some part of our brain to do routine work is at first the result of long individual experience, but that after a while it is in some measure transmitted, and may be considered as the property of the race—still the result of experience, though not necessarily of individual experience. We know that our ability to estimate depth is instantaneous, and we know that it is greater with two eyes than it is with one. Many of us have been taught to believe that the uniocular picture is a flat picture, but it is not, though under some circumstances one eye is not able to appreciate relief where two give easy and abundant evidence of it. It may not be that any of the more close students of the subject of binocular vision have believed that all our visual perceptions of depth were due to the binocular function; still it is very easy for one who reads on this subject to become possessed of that idea from what he reads.

The writer believes that the perception of depth in the binocular picture that presents itself to any adult who opens both eyes to see it is the result of experience gained either from his infancy or his ancestry, and that it may be, and sometimes is, the resultant of all the following impressions, viz.: That produced by

1. Parallax.
2. Focal perspective.
3. Aerial perspective.
4. Mathematical perspective and preconceived ideas and expectations.
5. Transparency of images or parts of images.
6. Incorrect superposition of images.
7. Doubling of images.
8. Change in binocular adjustments for different depths.
9. Ability to distinguish between homonymous and heteronymous diplopia.

The first four of the above conditions may exist in uniocular vision. The fifth may be either a uniocular or a binocular phenomenon. The last four can only be experienced by a person having two eyes. For 1 and 8 an appreciable amount of time is required; for all the others the perception may be instantaneous.

The writer believes also that the perception of relief may be, and often is, experienced through any one of these nine factors alone, or from two or more in combination, but that the uniocular sensations are as a rule much less vivid and impressive than the binocular; still they are important factors of the general resultant. For the perception of very great depth, where the interocular space may be considered as infinitely small compared with the distance, aerial perspective (3) is perhaps the most important and mathematical (4) next, though the effect of parallax voluntarily or accidentally obtained is in no way to be ignored. For all shorter distances the most vivid impressions of depth come from 2, 9, 5, and 4, and though the ability to distinguish between homonymous and crossed diplopia (9) may be considered the most important, it is sometimes entirely subordinated by mathematical perspective (4).

It is perhaps rather unusual to find all these elements working together for a single impression, but with all our looking and our constant motion there is hardly a moment of the day when we are not indebted for something to each one of them, except, of course, aerial perspective for in-door scenes.

It is also well known that these impressions, though very generally correct, are not always so. Exceptional cases occur in which either accident or design produces anomalous effects which, if single, are very likely to be deceptive; for example, a mist over one part of a landscape while the sun is over another will deceive us as to the relative distance unless there be some means of judging of it other than aerial perspective. On account of circumstances similar to these we may obtain through our eyes two different kinds of evidence in regard to depth, as when 4 and 9 are directly antagonistic in their evidence. These cases, though not so common in nature, are easily produced; and a very striking one is that referred to by Le Conte, in which the stereoscopic pictures of a street are mounted so as to produce, by the crossing of the images (6, 7, 8 and 9), just the opposite effect that is suggested by the aerial and mathematical perspective. In this case the prejudice is so great in favor of having the smaller objects measured by their angular size at the greater distance from us, and the ability to form mathematical judgments is so great that the entire binocular function seems to be ignored and it is impossible to be deceived, though according to the above classification 3 and 4 alone were opposed to 5, 6, 7, 8 and 9, while 1 and 2 were out of the argument. This is interesting as showing a strong evidence of what may be called uniocular stereoscopic vision.

As the eye in one twenty-four hundredth part of a second is capable of gathering in evidence of seven different kinds in regard to solidity and as in less than one-tenth of a second those two kinds that depend upon its rapid change of adjustment may be added, it is interesting to know what will be the result when there is not perfect agreement in the different kinds of data that are thus obtained. It would be natural to suppose that the resulting impression would be a kind of general average corresponding to the mechanical resultant in problems of physics. This is no doubt sometimes the case, but not always; or at least the resultant is so modified by or ments not purely visual that it cannot be called the visual resultant. In cases, for instance, where the mathematical and binocular perspective are directly opposed in their evidence, as in the one just quoted, it is impossible for us to believe that one of two objects is at the same time much nearer and much farther than the other, so the mind, as would be expected, decides on the relative validity of the two kinds of evidence and seems unhesitatingly and unconsciously to ignore the seemingly less reliable.

The hypotheses thus far treated of in a theoretical way concerning the causes of our stereoscopic sensations may be considered proved if, without the element of depth, we can reproduce the sensations at any time by reproducing the causes on which we believe them to depend and so isolated from other phenomena that there shall be no doubt of their constant connection with the sensations in question.

This is done most beautifully by the stereoscope, an instrument invented by Wheatstone for the purpose, and which in another form has since become a household article. The object of the stereoscope is to place at the same time before each eye a plane picture of some solid object or collection of solid objects; these pictures being nearly alike, but differing just as the retinal pictures would differ on account of the different positions of the two eyes. When such pictures are placed before the eyes and arranged in such a position that the directions of the visual axes and the focal adjustments of the eyes are the same as if they were looking at the real objects in space instead of the flat pictures of them, the results are so strikingly like the sensations produced by objects occupying three dimensions in space that they have only to be seen to be appreciated.

Wheatstone's instrument is not the one in common use, but is a reflecting instrument made by placing two mirrors together at an angle of nearly ninety degrees, as in Fig. 5145, the pictures being placed one on each side at l and r, and so reflected as to be seen as one solid picture when both eyes are directed to the point O. The effect, as everyone knows, is very striking. The same result would, of course, be obtained by placing each mirror at right angles to its present position and the pictures back to back between them. Sir David Brewster

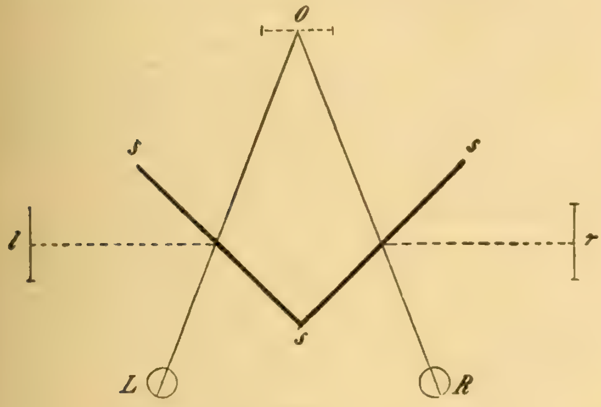


Fig. 5145.

was the inventor of the refracting stereoscope which, with slight modifications, is in use to-day. The older instruments were made like that pictured in Fig. 5146; the centre of each picture being placed directly in front of the corresponding eye, and before each eye, at P and P′, were prisms of such strength as to superimpose l and r at o. The screen s s prevented each eye from seeing the picture that belonged to the other. Each of the prisms in use at P and P′ was united with a convex lens, which was used principally for its magnifying effect, but which somewhat interfered with the sense of distance that would depend on the proper co-ordination of the convergence and the accommodation. In the stereoscopes that are most in use to-day this anomaly does not exist. The pictures are made so large that their centres are considerably outside of the axes of vision and the prisms are merely strong enough to bring the centres of the pictures so near together as to allow of their being seen when the visual axes are parallel, while the convexity of the lens is such as would correspond to the amount of accommodation that ought to be used to make distinct the picture at the distance at which it is really placed in the stereoscope. In this way the physiological condition of the eye in looking at a distant scene is exactly reproduced in looking at the plane pictures of the stereoscope, and the resulting deception is quite perfect. This latter form of stereoscope is seen in Fig. 5147.

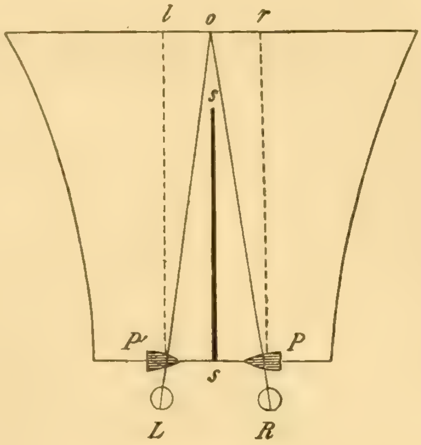


Fig. 5146.

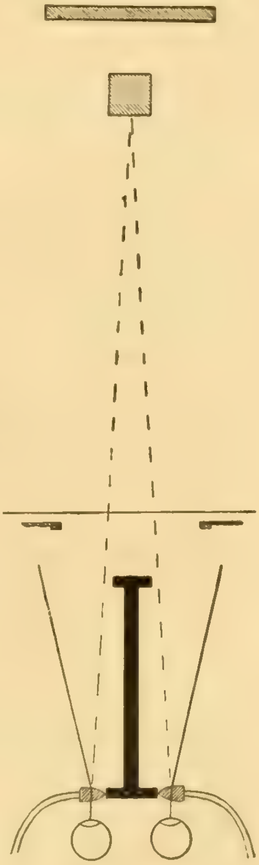


Fig. 5147.

Some of the stereoscopes in the shops to-day have no prisms at all in them, but are calculated to have the centre of each picture directly in front of the eye, while the lens is such as to supply the accommodation that would correspond to the distance at which the picture is really placed. The deception in this case is quite the same, the only disadvantage being in the limitation of the size of the picture in breadth to the interocular distance. There are other stereoscopes in which the superposition of the unlike images is brought about by different devices, but they all amount to the same thing and produce the same effects. One of the earlier forms was that invented by Dove (Fig. 5148), in which the displacement of the pictures is brought about by two right-angular convex prisms each producing two refractions and one total reflection.

Illustrative of the power of the stereoscope in giving the appearance of relief to plane figures, we may take the cut given by Gauss (Fig. 5149), which is the flat picture of a truncated pyramid with the smaller end directed toward the observer. The right-hand picture is the pyramid as it appears to the right eye, and the left is as it appears to the left eye. In the stereoscope neither eye can see the picture that is meant for the other. The prisms are arranged so that each picture falls on the most sensitive part of the retina when the eyes are in a position of rest, and the convex element in the prismatic glass makes the lines clear and distinct when the eye is focussed for distance. The result is that the two pictures fall as nearly on corresponding points as it is possible for two such different pictures to fall, and exactly the same effect is produced as if the eyes were looking at a truncated cone that was a great way off and that was large enough to fill up the same angular space that each picture fills. This gives the appearance of much greater size than can be attributed to the change brought about in the retinal image by the convex lens and it also gives the same appearance of solidity that would come from looking at a real one at the distance that would allow of its being seen with the axes practically parallel. Now if we look at this picture in the stereoscope we shall be able to see most of the phenomena that would have been presented if we were looking at the real cone in the position that this is supposed to occupy. We can even get the parallax in a slight degree by moving the head on account of the property which we recognize in the convex lens to displace eccentric pencils in a ratio that is increased with the eccentricity. We cannot, it is true, get the focal perspective, for the lens we use has practically a flat field, and the same accommodation, or lack of it, is needed for all parts of the picture; but as the visual axes are in this case parallel, the picture appears to be at a distance where focal adjustment is not an important factor in our estimation of depth. We have no aerial perspective, nor should we expect any, in a figure of no greater apparent depth than that is made to represent. There is nothing in it to oppose our ideas of mathematical perspective, and all the phenomena which give us a binocular perception of space-relations are fully represented. We have the imperfect superposition of images evident from the doubling that takes place in one part of the figure when we are looking at a part that is apparently more or less removed from us. We have the effect of transparency, or we should have, if the sides of the figure were shaded a little.

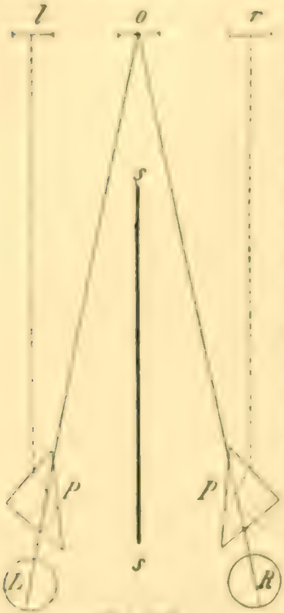


Fig. 5148.

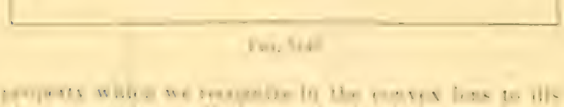


Fig. 5149.

If we transpose these pictures in Fig. 5149 the effect is obviously reversed, for the picture that is now seen by the right eye will then be such as would appear if we were looking into a hollow box instead of at a projecting pyramid, and the apparent central depth of the box will be just as striking as was the projecting centre of the pyramid. A stereoscope is not at all necessary to get these effects. A single prism held before one eye so as to displace both pictures enough for the right-hand picture as seen by one eye to fall on the left hand as seen by the other, will give precisely the same effect, only slightly modified by the fact that as we are obliged to use the accommodation the apparent distance will be a little decreased; and whether we see the picture of a pyramid or a box will depend on whether we hold the prism so as to displace the pictures inwardly or outwardly. Indeed, with a little practice no apparatus of any kind is necessary; we have but to diverge or converge the optic axes as we look, so that one eye points at one picture and the other eye at the other picture, and then wait a moment until the lens adjusts itself to the anomalous position, and we shall get the stereoscopic effect as vividly or nearly so, as if we had an instrument to aid in the illusion. Those who have difficulty in doing this will be aided if, when trying to make the axes diverge, they imagine themselves to be looking straight through the central point of the card at some imaginary point a long distance beyond; or, if this does not answer, it may be of greater help to look over the top of the card and fix the eyes on some real distant point when the images will be seen to double like those of the hand in a previous experiment.

It is very hard to fuse the modern stereoscopic pictures in this way, because the distance between the centres is usually greater than the interocular distance, and none of us have ever any need to diverge the eyes in actual life, and few of us are able to do so voluntarily; but any of the diagrams here printed as stereoscopic cards can be easily fused after a little practice, either by divergence or crossing, the relief in the one case being just the opposite of that in the other.

The experimenter may aid himself in crossing the eyes by holding the point of a pencil midway between the two pictures and fixing on that, and, while looking at it, withdraw it toward himself until the diplopia produced is just enough to place one picture over the other. In either of the last two cases the central picture will be the stereoscopic one, while on either side of that will be seen the two monocular pictures that are not visible in the stereoscope on account of the central screen.

As would be supposed, the stereoscope offers great advantages to the experimenter who is desirous of taking up, one at a time, the causes that tend to give the notion of solidity and testing their value as contrasted with other phenomena. Though something has been done in this line, the writer is not sure that anyone has attempted to go over the elements as classified above and make out a table in which each one should receive its comparative value in a quantitative as well as a qualitative way. This would be a most interesting thing to do, and would be another step among the many that are being taken nowadays toward making ours an exact science, and a comparatively easy step, too, for so much has already been done in detail that it seems as if only a little repetition and invention were necessary before the whole could be shaken together so that the different values of the elements and their combinations would be known.

There have been many experiments since the time of Brewster bearing on this point, but it seems now as if the time were ripe for the classifying and assigning definite values or, at least, relative values, and the stereoscope gives us many useful hints; e.g., in Fig. 5150, published by Dr. Green, after Brewster, the element of convergence alone, which is needed in a greater degree for the fusion of the right- than the left-hand image, produces very marked deception in regard to both size and distance of the two squares.

Before leaving the stereoscope, the telestereoscope ought to be mentioned. It is an instrument invented by Helmholtz for increasing our power to estimate distance by practically increasing the interocular space. This is done by the aid of four mirrors or reflecting surfaces, so arranged (Fig. 5150) that while the eyes look toward the object the pictures formed on the retina are such as would be there formed if the eyes were as far apart as the two outside mirrors.

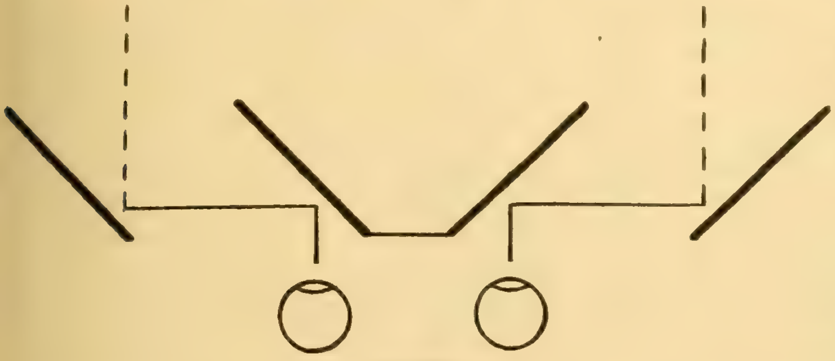


FIG. 5150.

The horopter is something that ought not to be trifled with by anyone who is not fond of pure mathematics. That there is such a thing no one will doubt, but it is much easier to define than to describe it. It is the locus of all those points in space that are at the same time so situated that their images on the two retinæ fall on corresponding points. To illustrate, let both eyes be directed, as in Fig. 5138, to the point A, the two visual axes in this case being represented by A a and A a′. Now any point, as B, so situated in space that the angle B D A is equal to the angle B S A, and of the same sense, will be so situated that its image will fall on corresponding points of the retinæ, and it will be seen single when both eyes are looking at A, and the sum of all the possible situations for such points, *i.e.*, what is known in geometry as the locus of a point subject to those conditions, is the horopter. Of course, the horopter changes for every change of the point of fixation.

When we begin to investigate the properties of the horopter our task seems as easy and as plain sailing as one of Euclid's propositions, and we soon obtain what is known as the horopteric circle of Mueller, given in Fig. 5138. This is that part of the horopter that cuts a horizontal plane passing through the eyes, and we see by it, or we seem to see by it, that all those points lying on the horizon that are seen single will be in a circle drawn through the nodal points of the eyes. This assertion depends upon the supposition that the vertical meridian in each eye remains vertical under all degrees of convergence, and upon the well-known geometrical truths that vertical angles are equal, that the sum of the internal angles of a triangle is equal to a constant quantity, and that inscribed angles subtended by the same chord are equal; from this we go on a step further, to develop this horopteric line into a horopteric surface by revolving it round the chord D S. The surface of revolution thus formed is known as a torus, a section of which is shown in Fig. 5151, and that part of it which is included in the field of vision is what would be the horopter if the conditions thus named held good. But the conditions do not hold good, for, as has been shown by Listing and others, the vertical meridians of the eyes do not remain vertical under convergence, and so the horopter above described is only correctly estimated for distances so great as to be practically infinite, and then the spherical surface that represents the horopter is a plane at infinity. It is hardly possible, in a short article like this, to follow all the researches that have been made on the actual shape of the horopter. The results of what has been done toward the determination of its true shape are thus summed up by Professor Le Conte:

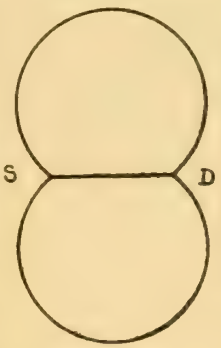


FIG. 5151.

"In regard to the horopter, I consider the following points to be well established. 1. As a necessary consequence of the outward rotation of the eyes in convergence for all distances in the primary visual plane, the horopter is a line inclined to the visual plane, the lower end nearer the observer. But whether the inclination is constant, or increases or decreases with distance, I have not been able to determine with certainty. It is probably constant.

"2. In depressing the visual plane the inclination of the horopteric line becomes less and less until, when the visual plane is inclined forty-five degrees below the primary position, the horopteric line becomes perpendicular to the visual plane and at the same time expands into a surface. The exact nature of the surface I have not attempted to investigate, but it is evidently a curved surface.

"3. In elevating the visual plane, especially with strong convergence, the inclination of the horopteric line increases."

Before leaving the horopter in this very unfinished state, it is interesting to note that the shape of the horopter has been suggested as having something to do with our usual impression in regard to the shape of the sky, which seems to form a concave surface over our heads. It seems rather doubtful whether this is the case.

The horopter has also, like so many of the binocular phenomena, a faint foreshadowing in the uniocular field: thus in Fig. 5133 the points A, B, and C may be taken as illustrative of the fact that the eye has not a flat field, and that each one of the many points marked on the retina must have somewhere in space a conjugate focus and those in the periphery of the field will be farther from the eye than those directly in front. The exact position cannot be definitely stated on account of the astigmatism of eccentric pencils; but this would seem to be of little importance, because of the comparative insensibility of the periphery of the retina, and because of our habit of turning the eye toward anything that we wish to see distinctly. In the same way, it does not seem to matter much in every-day affairs where the horopter goes to after it has passed out very far from the central field, but it is necessary to know something of the position of its uniocular prototype in making experiments for the determination of the relative visual acuteness of the different parts of the retina.

The writer is obliged to pass over, with only very brief mention, a number of beautiful diagrams published by Professor Le Conte in his book on sight, illustrative of the fact that we do not seem to see objects as with two separate eyes, one of which is in one position and one in another; but we have apparently only one visual field, and, as we look out into the world, we seem to be looking as if out of a single eye to be fixed midway between the two that we really use. In these diagrams we have a representation of what each eye really sees, and, besides this, of the object as it appears to us after being transferred by the mind to its true position as regards ourselves, i.e., to the place that it seems to occupy relative to an imaginary eye in the middle of the interocular space.

A word or two ought to be said in regard to the importance of a comparatively poor eye to the binocular combination.

As has been before remarked, two eyes do not see a plane surface where there is no perspective or relief very much better than one, but it is surprising how much a very poor eye will add to the ability to judge of distance. The lens of the organ may be wanting entirely, and the cornea be somewhat clouded with opacities, and yet the eye have the ability to direct itself with considerable precision; and as long as that is the case, great help will be given to the judgment of distance, as might be supposed from the importance that convergence plays in making up the estimation (see Fig. 5141, illustrative of this point). This is not only useful to the patient in many every-day affairs, such as judging of the height of a step, but, besides this, the pertinacity that is shown in many patients who have eyes that can in no way form images on the retinæ nearly enough alike to admit of their being fused in the ordinary acceptation of the term—the pertinacity that is shown by them in continuing to use both eyes together, instead of ignoring one and letting it turn out or up when some kind of trouble makes it much easier for them to do this, is quite significant of the amount of help that can be got from a comparatively poor organ. The writer cannot close this paper without expressing his sincere thanks to Dr. John Green, of St. Louis, for the very material aid that he has given, and his sorrow that the hurried manner in which it has been written makes it so little apparent that he has had the advantage of that help, and also of the very excellent book on the subject written by Professor Le Conte, of which he has made considerable use, though less than he would have made had time and space permitted.

W. S. Dennett.

VITILIGO. This affection of the skin, which is likewise known by the name of leucoderma, consists in the development of whitened areas upon various portions of the body, but especially of the face, neck, and hands. It is due to localized loss of pigment in rounded or ovoid patches of various size, having sharply defined margins and surrounded by more or less deeply pigmented skin which gradually shades off into the normal. The characteristic features of the whitened spots are that their border is usually convex, giving the impression that they extend into their darkened surroundings, or in their advance drive the pigment before them; that there is no change in the structure, sensations, or secretions of the affected areas; and that their tendency is to persist and to increase in extent, being little affected by any treatment. It is an acquired condition coming on usually in youth or early adult life without previous ill-health or prodromata, though in some instances it has been known to follow local injury and sometimes develops in the neighborhood of a pigmented mole. The dark-skinned races are rather more subject to vitiligo than those of fair skin and light hair, and it is not so very rarely seen in the negroes of this country, in whom the contrast between the perfectly white spots and the normal skin produces a striking effect. I have seen instances where much discomfort of mind was occasioned by the fact that the white patches were merging into each other until extensive regions of the body had lost their pigment, and the negro was fearful that he was "turning into a white man." The hair may lose its pigment in the same way as the skin, and rounded or irregular tufts of gray may appear upon the head. In white races the affected regions are often more noticeable in the summer time, when the surrounding pigmentation becomes deeper.

The *diagnosis* of vitiligo is not difficult, although it is liable to be confounded with morphœa, chloasma, tinea versicolor, syphilitic pigmentations, macular leprosy, and albinismus. One chief point by which it is distinguished from other conditions is the normal condition of the skin, apart from its loss of pigment. In morphœa there are structural changes. In tinea versicolor the patches are inflammatory and scaly, and from them scales can be scraped which show, under the microscope, the characteristic groups of spores, although when circumscribed areas of healthy white skin are enclosed in the brownish patches of this disease, vitiligo may be closely simulated; but the margins will be found irregular instead of clean-cut. In chloasma there is increased pigmentation of the patch itself and the circumference is the part which appears white. The distinction has been made that in vitiligo the margin of the white area is convex toward that which is pigmented while in chloasma it is concave, but in some instances the patches run together in such a way that this becomes more theoretical than apparent. Syphilitic pigmentations, especially about the neck in women, may persist after other manifestations have disappeared and simulate vitiligo. In the macular form of lepra the patches of white skin have an irregular outline, not so abrupt as in vitiligo, and the tinge is rather grayish than dead white; then, too, the skin is either thickened or atrophied and anæsthesia or impaired sensation is present. Finally, in albinism we have, as in vitiligo, an absence of normal pigment, but in the former it is a congenital defect and the whole surface of the body, including the hair and eyes, may be devoid of pigment.

The *etiology* of vitiligo is not well understood, but the cause of the condition is usually ascribed to perverted innervation. It is probable that the disappearance of the pigment from one spot and its increased deposit in a neighboring part is due to an atrophy and hypertrophy in the respective regions brought about through the sympathetic nerve system. Sometimes, though rarely, the proper proportion of pigmentation is spontaneously restored, but in the majority of instances the affected areas tend to increase, and the condition to assume marked chronicity. When large extents of surface are involved the term leucoderma becomes appropriate.

The *treatment* is unsatisfactory. Some reports of success from electricity have been made. Local applications for the removal of surrounding pigmentation are resorted to with the view of rendering the white regions less noticeable. Internally, nerve tonics, especially strychnia and arsenic, are advised. Blistering the patches to excite a deposit of pigment has been tried, but the results are not brilliant. If upon the face or other exposed part, artificial staining may be employed, and dyes used to restore the color of the hair.

Charles W. Allen.

GENERAL INDEX.

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